

The Edwards Air Force Base Installation Restoration Program

An Investment Report





April 2000





Over the last decade the Edwards Air Force Base (AFB), California, Installation Restoration Program (IRP) has adjusted to many changes to the Congressional- and Department of Defense (DoD)-established program premises, goals, and objectives. In addition to changing Restoration Program expectations, the civil service project managers, Base senior leadership, concerned community, Restoration Advisory Board (RAB) members, and support contractors continually change over time. Questions about Restoration Program strategies, objectives, and procedures are frequently asked by people who are new to the Base and the Antelope Valley.

The Management Action Plan (MAP), **Environmental Management Restoration Division** (EMR) Business Plan, and Comprehensive Remedial Investigation/Feasibility Study (RI/FS) Management Plan present important facts about the Edwards AFB IRP and how its performance is measured. However, these plans were not prepared to address in simple language the most frequently asked questions about how the Base is being cleaned up or to present a coherent overview of the strategies used in the management of the IRP. It is hoped that this Investment Report will augment and complement the other plans by providing those interested in restoration with a compendium of over 87 strategies and techniques used by the EMR at Edwards AFB, California. The presentation of each strategy, technique, or experience is intentionally brief. It has been prepared to provide the reader with a quick overview of how the strategy is applied, when the strategy was first tried, and the benefits the program gained from using it.

The Investment Report is presented in eight chapters. Chapter 1 presents Edwards AFB's philosophy and approach to the IRP and Chapter 2 provides an overview of its formal cleanup strategy. Chapter 3 describes Edwards AFB's twenty-four programmatic investments. Chapters 4, 5, 6, and 7 present Edwards' modern, bold, and very successful approaches to investigation, information management, risk reduction, and community involvement. Chapter 8 highlights the effect of the Edwards AFB IRP on the economy of the Antelope Valley.

Although the Base is eager to try new methods of investigation and restoration, it is also ever vigilant that its efforts are cost effective and will lead to more efficient program management and site closure. We cite examples of how the strategies have been effective and have been a wise use of Restoration Program resources.

There is no single best way to investigate a hazardous waste site, to communicate its risk to the public and the regulatory agencies, or to most cost-effectively clean it up. The strategies and techniques that have been successful at Edwards AFB have been those that have the support of the regulatory agencies, RAB members, and the general public. The key to the success of each strategy and technique has been open and honest communication, trust, and teamwork. No action is taken until Edwards AFB and the regulatory agencies are convinced that it can be accomplished safely, that it is a reasonable action likely to achieve the proposed objectives, and that the action is worth the investment of the time and resources.

TABLE OF CONTENTS

| CHAPTER 1 | Introduction to Edwards Air Force Base and Its Installation Restoration Program | 1-1 |
|-----------|---|------|
| Purpose | e of the Document | 1-3 |
| | ds AFB's Strategies and Approach | |
| CHAPTER 2 | Edwards AFB's Simple, Step-Wise Cleanup Strategy | |
| | Twenty-Four Programmatic Investments | |
| | | |
| _ | te RCRA and CERCLA Programs | |
| | Learned: CERCLA Does Not Scale Up Well | |
| | ze OUs Using Risk to Residents and Employees | 3-3 |
| _ | mmatic National Environmental Policy Act Documentation in 1991, | 2.4 |
| - | uires Best Management Practices | |
| | tently Use Timely Cultural and Historical Surveys to Clear Digging Permits | |
| _ | te, Early Biological Opinions for OU Investigations | |
| _ | mmatic Revegetation Plan in 1993 | |
| | s a Test Bed | 3-6 |
| | ly Plan for File Organization, Information Repositories, and for the | 2.6 |
| | ninistrative Record | |
| | nd Presumptive Remedies Speed Risk Reduction and Site Closure | |
| _ | gness to Test Experimental Techniques | |
| - | g Information on Formerly-Used Defense Sites | |
| | Attenuation Occurring All The Time | |
| | pment of Background Metals Concentrations | |
| | Critical Removal Actions | |
| _ | CERCLA to Clean Up RCRA OB/OD Sites | |
| | up Requirement Information System" Software | |
| • | ing Clean and Treated Soil as Landfill Cover and Backfill | |
| _ | g Unexploded Ordnance and Addressing the Risks | |
| | sing UXO Risk at IRP Sites | |
| | Inking Using Relative Risk | |
| | s are Primary Documents; Schedules are Enforceable | |
| | le Base-wide ROD, HRA, and ERA | |
| Suppor | ting the Role of the Natural Resource Trustees | 3-16 |
| CHAPTER 4 | Innovative Investigation Techniques | 4-1 |
| Well-R | easoned Data Quality Objectives | 4-2 |
| | thy of Investigation Methods | |
| | al Research | |
| | ews With Retired Employees | |
| | Geophysics | |
| | c Profiling of the Subsurface | |
| | Remote Sensing | 4-5 |

| Soil Gas Analyses Cone Penetrometer Testing With Rapid Optical Screening Tool Sampling, Technology Assessment, and Remediation (STAR) Rig Boreholes and Monitoring Wells Downhole Video Assessments Tracer Studies Establishment of the Base Environmental Analytical Laboratory Evaluation of Thermal Oxidizers for Dioxin Formation Investigation of Homestead Wells. Sampling Off-site Wells for Perchlorate CHAPTER 5 Turning Data Into Information The Geographic Information System (GIS) Creation of Groundwater Models. Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCILA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | | | |
|--|--|-----|-----|
| Sampling, Technology Assessment, and Remediation (STAR) Rig Boreholes and Monitoring Wells Downhole Video Assessments Tracer Studies Establishment of the Base Environmental Analytical Laboratory Evaluation of Thermal Oxidizers for Dioxin Formation Investigation of Homestead Wells. Sampling Off-site Wells for Perchlorate CHAPTER 5 Turning Data Into Information The Geographic Information System (GIS) Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | • | | |
| Boreholes and Monitoring Wells Downhole Video Assessments Tracer Studies Establishment of the Base Environmental Analytical Laboratory Evaluation of Thermal Oxidizers for Dioxin Formation Investigation of Homestead Wells. Sampling Off-site Wells for Perchlorate CHAPTER 5 Turning Data Into Information The Geographic Information System (GIS) Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | | | |
| Downhole Video Assessments Tracer Studies Establishment of the Base Environmental Analytical Laboratory Evaluation of Thermal Oxidizers for Dioxin Formation Investigation of Homestead Wells Sampling Off-site Wells for Perchlorate CHAPTER 5 Turning Data Into Information The Geographic Information System (GIS) Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure Base-wide Initiatives Natural Attenuation. Background Metals Studies Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | 2 0 | | |
| Tracer Studies Establishment of the Base Environmental Analytical Laboratory Evaluation of Thermal Oxidizers for Dioxin Formation Investigation of Homestead Wells. Sampling Off-site Wells for Perchlorate CHAPTER 5 Turning Data Into Information The Geographic Information System (GIS) Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure Base-wide Initiatives Natural Attenuation. Background Metals Studies Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | <u> </u> | | |
| Establishment of the Base Environmental Analytical Laboratory Evaluation of Thermal Oxidizers for Dioxin Formation Investigation of Homestead Wells. Sampling Off-site Wells for Perchlorate CHAPTER 5 Turning Data Into Information The Geographic Information System (GIS) Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426 Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | | | |
| Evaluation of Thermal Oxidizers for Dioxin Formation Investigation of Homestead Wells Sampling Off-site Wells for Perchlorate CHAPTER 5 Turning Data Into Information The Geographic Information System (GIS) Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426 Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | | | |
| Investigation of Homestead Wells | • | • | |
| CHAPTER 5 Turning Data Into Information The Geographic Information System (GIS) Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426 Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | | | |
| CHAPTER 5 Turning Data Into Information The Geographic Information System (GIS) Creation of Groundwater Models Development of an AFRIMIS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | • | | |
| The Geographic Information System (GIS) Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure Base-wide Initiatives Natural Attenuation Background Metals Studies Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Sampling Off-site Wells for Perchlorate | 4-1 | 3، |
| Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies. Bioventing Oual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | CHAPTER 5 Turning Data Into Information | 5 | -1 |
| Creation of Groundwater Models Development of an AFRIMS Integrated Supplemental Database Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies. Bioventing Oual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | The Geographic Information System (GIS) | 5- | - 1 |
| Development of an AFRIMS Integrated Supplemental Database. Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping. Mobile Free-Product Recovery Unit (MFRU) | | | |
| Development of Background Metals Concentrations Document Management CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure Base-wide Initiatives Natural Attenuation Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426 Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | | | |
| CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426 Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | | | |
| CHAPTER 6 Cleanup and Risk Reduction Methods A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426 Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping. Mobile Free-Product Recovery Unit (MFRU) | • | | |
| A Willingness to Try Experimental Techniques Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Document Management | | J |
| Using CERCLA's Flexibility to Reduce Risk Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | CHAPTER 6 Cleanup and Risk Reduction Methods | | -1 |
| Pentaborane Destruction Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | A Willingness to Try Experimental Techniques | | -2 |
| Short-Range Attack Missile Removal Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426 Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Using CERCLA's Flexibility to Reduce Risk | 6- | -2 |
| Inactive Landfill Closure. Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426 Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Pentaborane Destruction | 6- | -2 |
| Base-wide Initiatives Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Short-Range Attack Missile Removal | 6- | -3 |
| Natural Attenuation. Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Inactive Landfill Closure | 6- | -3 |
| Background Metals Studies. Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Base-wide Initiatives | 6- | -4 |
| Chemical Warfare Materiel (CWM) Management Evaluation of CWM at Site 426 Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Natural Attenuation | 6- | -4 |
| Evaluation of CWM at Site 426. Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing. Dual Extraction (DE). Bioslurping. Mobile Free-Product Recovery Unit (MFRU). | Background Metals Studies | 6- | -5 |
| Unexploded Ordnance Management Shallow Soil Risk Reduction Methods Underground Storage Tank Removal Soil Excavation Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Chemical Warfare Materiel (CWM) Management | 6- | -5 |
| Shallow Soil Risk Reduction Methods Underground Storage Tank Removal. Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing. Dual Extraction (DE). Bioslurping. Mobile Free-Product Recovery Unit (MFRU). | Evaluation of CWM at Site 426 | 6- | -5 |
| Underground Storage Tank Removal Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Unexploded Ordnance Management | | -6 |
| Soil Excavation. Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing. Dual Extraction (DE). Bioslurping. Mobile Free-Product Recovery Unit (MFRU). | Shallow Soil Risk Reduction Methods | 6- | -6 |
| Establishment of a Soil Treatment Farm Drill Cuttings and Clean Overburden Management Beryllium Burial. Established Risk Reduction Technologies. Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Underground Storage Tank Removal | 6- | -7 |
| Drill Cuttings and Clean Overburden Management Beryllium Burial Established Risk Reduction Technologies Bioventing Dual Extraction (DE) Bioslurping Mobile Free-Product Recovery Unit (MFRU) | Soil Excavation | 6- | -7 |
| Beryllium Burial | Establishment of a Soil Treatment Farm | 6- | -8 |
| Established Risk Reduction Technologies Bioventing | Drill Cuttings and Clean Overburden Management | | -8 |
| Bioventing 6 Dual Extraction (DE) 6 Bioslurping 6 Mobile Free-Product Recovery Unit (MFRU) 6 | Beryllium Burial | | -9 |
| Dual Extraction (DE) 6 Bioslurping 6 Mobile Free-Product Recovery Unit (MFRU) 6 | Established Risk Reduction Technologies | 6- | -9 |
| Bioslurping | Bioventing | 6-1 | 0 |
| Mobile Free-Product Recovery Unit (MFRU) | Dual Extraction (DE) | 6-1 | 0 |
| Mobile Free-Product Recovery Unit (MFRU) | Bioslurping | 6-1 | 1 |
| | | | |
| Air Sparging/Soil Vapor Extraction (AS/SVE) | | | |

| Experimental Techniques | 6-13 |
|---|---|
| Cometabolic Biodegradation of Trichloroethene | 6-13 |
| Oxygen-Releasing Compounds (ORCs) | 6-14 |
| In-Well Vapor Stripping | 6-14 |
| Ammonium Perchlorate Treatment | 6-15 |
| Use of Granular Activated Carbon | 6-16 |
| Biofiltration | 6-16 |
| Use of Internal Combustion Engines | 6-17 |
| Other New Cost-Avoidance Techniques | 6-17 |
| Micropurging Groundwater Wells | 6-18 |
| Supervisory Control and Data Acquisition System (SCADA) | 6-19 |
| Skid-Mounted Equipment | 6-19 |
| Long-Term Monitoring (LTM) as a Remedial Alternative | 6-20 |
| Institutional Controls (ICs) as a Risk Reduction Method | 6-20 |
| Hazard and Fault Analyses at LTO Sites | 6-20 |
| | |
| CHAPTER 7 Community Involvement Initiatives | 7-1 |
| • | |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR |)7-1 |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB | 7-1 |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB. The RAB's "Tool Kit" |)7-1 7-2 7-3 |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB. The RAB's "Tool Kit" | |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB. The RAB's "Tool Kit". Professional Videos Our Monthly Status Report. | .) |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB. The RAB's "Tool Kit" | |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB. The RAB's "Tool Kit". Professional Videos Our Monthly Status Report Placing Documents on the Internet. IRP Site Tours. | .) |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB. The RAB's "Tool Kit". Professional Videos. Our Monthly Status Report. Placing Documents on the Internet. IRP Site Tours. Information Packets for "NFI" Tours | 7-1 7-2 7-3 7-4 7-5 7-6 7-6 |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB. The RAB's "Tool Kit". Professional Videos Our Monthly Status Report Placing Documents on the Internet. IRP Site Tours Information Packets for "NFI" Tours Sampling Neighbors' Water Wells | |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB. The RAB's "Tool Kit". Professional Videos. Our Monthly Status Report. Placing Documents on the Internet. IRP Site Tours. Information Packets for "NFI" Tours. Sampling Neighbors' Water Wells "Public Health Assessment Information Support Document" Prepared for ATSDR's Inspection | .) |
| An Early Plan for File Organization, Information Repositories, and the Administrative Record (AR Formation and Training of our RAB. The RAB's "Tool Kit". Professional Videos Our Monthly Status Report Placing Documents on the Internet. IRP Site Tours Information Packets for "NFI" Tours Sampling Neighbors' Water Wells | |

ALPHABETICAL INDEX

LIST OF FIGURES

| Figur No. | e | Page No |
|------------------------|--|------------|
| 1-1 | Location of Edwards Air Force Base | |
| 1-2 | Edwards Air Force Base Installation Restoration Program Remedial Project Managers | |
| 1-3 | Edwards Air Force Base Operable Unit Number and Description. | |
| 2-1 | Edwards Air Force Base Overall Cleanup Strategy. | |
| 3-1 | Our Remedial Investigation is Documented in 17 Volumes. | |
| 3-1 3-2 | Dual Extraction System Interim Removal Action at Site 45 | |
| 3-2 3-3 | Edwards Air Force Base Operable Unit Number and Description. | |
| 3-3 3-4 | Programmatic Documents Help Most When Done Very Early in the Program. | |
| 3- 4 3-5 | Aerial Photo of Muroc Army Air Field | |
| 3-6 | The Programmatic Revegetation Plan Tells EMR Where and How Much Vegetation to Replant | 5-5 |
| 5 0 | Based on the Amount of Vegetation Disturbed. | 3-6 |
| 3-7 | OU1 is the First Test Bed for Remedial Technologies. | |
| 3-8 | The Administrative Record Library | |
| 3-9 | Relative Savings in Reporting Requirements Under the Accelerated CERCLA Process | |
| 3-10 | The Air Force Flight Test Center, A Willingness to Test Experimental Techniques | |
| 3-11 | David Price at Edwards FUDS. | |
| 3-12 | TCE Groundwater Contaminated Plume Measured in µg/L | 3-9 |
| 3-13 | SRAM Missile | 3-11 |
| 3-14 | Edwards Air Force Base Open Burn Site | |
| 3-15 | Cleanup Requirement Information System Database | 3-12 |
| 3-16 | Edwards Air Force Base Soil Farm | 3-13 |
| 3-17 | Edwards Air Force Base Conventional Ordnance Ranges and Targets | 3-14 |
| 3-18 | Multispectral Imagery of Surface Bomb Locations | 3-14 |
| 3-19 | Single, Base-wide ROD, HRA, and ERA Will Save Millions of Dollars | 3-16 |
| 4-1 | Creating Smart DQOs | 4-2 |
| 4-2 | Edwards Air Force Base Hierarchy of Investigation Methods | 4-3 |
| 4-3 | Chemical Weapons Training at Edwards Air Force Base in the 1940s | |
| 4-4 | Interviewing Retired Employees | 4-4 |
| 4-5 | Field Image and Seismic Profiling Method (Vertical Line on the Field Shows the | |
| | Probable Fracture Zone) | |
| 4-6 | Helicopter Carrying a Magnetometer | |
| 4-7 | Aerial Remote Sensing Output (Locations of Metal Objects in Pink Color) | |
| 4-8 | Passive Soil Gas Collection Technique. | |
| 4-9 | Active Soil Gas Surveys | |
| 4-10 | Cone Penetrometer Equipment Drilling a Borehole on Rogers Dry Lake Using the STAR Rig | |
| 4-11 4-12 | Monitoring Well Installation | |
| 4-12 4-13 | Logging Soil Borehole Samples. | |
| 4-13 4-14 | Inserting a Downhole Video Camera into a Well | |
| 4-15 | Image Looking Down Into a Soil Boring With a Downhole Video Camera | |
| 4-15 4-16 | Map of Tracer Studies | |
| 4-10 4-17 | The Base Environmental Analytical Laboratory (BEAL) | |
| 4-18 | Testing for Dioxins in a Thermal Oxidizer | |
| 4-19 | Collecting Data at an Air Monitoring Station | |
| | | |

| 4-20 | Homesteaders Drilling a Water Well | . 4-12 |
|------------------------|--|--------|
| 4-21 | Edwards Air Force Base Location of Homestead Wells | . 4-13 |
| 4-22 | Sampling Groundwater | |
| 5-1 | Two-Dimensional GIS Map of Groundwater Plume with TCE Concentration Contours | 5 1 |
| 5-1 5-2 | Main Base Plume Map | |
| 5-2 5-3 | AFRIMS Integrated Supplemental Database | |
| 5-3 5-4 | Document Organization in the IRP Library | |
| 5- 4 5-5 | Older Hard Copy Documents Being Scanned into Electronic Files | |
| J-J | Older Hard Copy Documents being Scanned into Electronic Files | 5-5 |
| 6-1 | Steel Cylinders of Pentaborane | 6-2 |
| 6-2 | Controlled Open Burning of Corroded or Damaged Pentaborane Cylinders | |
| 6-3 | Inactive Landfill Groundwater Contamination | 6-3 |
| 6-4 | Microorganisms Like These are Responsible for Natural Attenuation | |
| 6-5 | Edwards Air Force Base Known Target and Bomb Drop Areas | 6-6 |
| 6-6 | UST Removal | |
| 6-7 | Tar Pit Discovered by a RAB Member and Subsequently Cleaned Up | |
| 6-8 | Edwards Air Force Base Soil Farm | |
| 6-9 | Managing IDW at a Drilling Site | 6-9 |
| 6-10 | Beryllium-impacted Soil Disposal | |
| 6-11 | Ceremony to Shut Down Bioventing System at Site 43 | . 6-10 |
| 6-12 | Line Diagram of Dual Extraction System. | . 6-11 |
| 6-13 | A Mobile Free-product Recovery System | . 6-12 |
| 6-14 | Mobile Free-Product Recovery System Schematic | |
| 6-15 | Air Sparging/Soil Vapor Extraction | |
| 6-16 | Bacteria Degrade TCE | |
| 6-17 | Biodegradation of Contaminants with Oxygen-Releasing Compounds | . 6-14 |
| 6-18 | In-Well Vapor Stripping Test | 6-15 |
| 6-19 | Calgon Ion Exchange Unit. | |
| 6-20 | Biotrickling Filter | |
| 6-21 | Internal Combustion Engine Unit. | |
| 6-22 | Micropurge and Conventional Sampling in Monitoring Wells | |
| 6-23 | SCADA System | |
| 6-24 | Skid-mounted Equipment on Pad | . 6-19 |
| 7-1 | Hours of Operation for our Information Repositories | 7-2 |
| 7-2 | The Report to Stakeholders | |
| 7-3 | RAB Off-Site Training | |
| 7-4 | Environmental Management's Video Kiosk | |
| 7-5 | Professional Videos | |
| 7-6 | Status Report, September 1999 | |
| 7-7 | IRP Site Tour. | |
| 7-8 | Sampling Water Wells | |
| | | |
| 8-1 | Edwards Air Force Base IRP Funding by Fiscal Year 1984-2000 | 8-1 |

LIST OF ACRONYMS

| | | T. 773. f | T |
|---------|--|-----------|--|
| AFB | Air Force Base | LTM | Long-Term Monitoring |
| AFCEE | Air Force Center for Environmental | LTO | Long-Term Operation |
| | Excellence | MAP | Management Action Plan |
| AFFTC | Air Force Flight Test Center | MCL | Maximum Contaminant Level |
| AFRIMS | Air Force Restoration Information | MNA | Monitored Natural Attenuation |
| | Management System | MSR | Monthly Status Report |
| AFRL | Air Force Research Laboratory | NA | Natural Attenuation |
| AOC | Area of Concern | NASA | National Aeronautics and Space |
| AR | Administrative Record | | Administration |
| ARARs | Applicable or Relevant and Appropriate | NEPA | National Environmental Policy Act |
| | Requirements | NFI | No Further Investigation |
| AS | Air Sparging | NFRAP | No Further Remedial Action Planned |
| ATSDR | Agency for Toxic Substances and Disease | NPL | National Priorities List |
| | Registry | OB | Open Burn |
| BEAL | Base Environmental Analytical Laboratory | OCR | Optical Character Recognition |
| BHPO | Base Historic Preservation Officer | OD | Open Detonation |
| BTEX | Benzene, Toluene, Ethylbenzene, and | OI | Operating Instruction |
| | Xylenes | O&M | Operation and Maintenance |
| CERCLA | Comprehensive Environmental Response, | ORC | Oxygen-Releasing Compound |
| | Compensation, and Liability Act | OU | Operable Unit |
| CPT | Cone Penetrometer Testing | PA/SI | Preliminary Assessment/Site Inspection |
| CRIS | Cleanup Requirement Information System | PHA | Public Health Assessment |
| CWM | Chemical Warfare Materiel | ppb | parts per billion |
| DHS | California Department of Health Services | ppm | parts per million |
| DoD | Department of Defense | PM | Project Manager |
| DQO(s) | Data Quality Objective(s) | PRG | Preliminary Remediation Goal |
| DTSC | Department of Toxic Substances Control | PRL | Potential Release Location |
| EA | Environmental Assessment | RAB | Restoration Advisory Board |
| EE/CA | Engineering Evaluation/Cost Analysis | RCRA | Resource Conservation and Recovery Act |
| EMR | Environmental Restoration Division | RI/FS | Remedial Investigation/Feasibility Study |
| ERA | Ecological Risk Assessment | ROD | Record of Decision |
| ESI/RFA | Expanded Source Investigation/RCRA | ROST | Rapid Optical Screening Tool |
| | Facility Assessment | RPM | Remedial Project Manager |
| FFA | Federal Facility Agreement | RWQCB | Regional Water Quality Control Board |
| FONSI | Finding of No Significant Impact | SACM | Superfund Accelerated Cleanup Model |
| FUDS | Formerly-Used Defense Sites | SCADA | Supervisory Control and Data Acquisition |
| GAC | Granular Activated Carbon | SRAM | Short-Range Attack Missile |
| GIS | Geographic Information System | STAR | Sampling, Technology Assessment, and |
| GPR | Ground-Penetrating Radar | | Remediation |
| HRA | Health Risk Assessment | SWMU | Solid Waste Management Unit |
| HSC | Human Systems Center | SVE | Soil Vapor Extraction |
| IC | Internal Combustion | TCE | Trichloroethene |
| IDW | Investigative-Derived Waste | TMO | Toluene Monoxygenase |
| IR | Information Repository | TRC | Technical Review Committee |
| IRA | Interim Removal Action | TS | Treatability Study |
| IRP | Installation Restoration Program | USFWS | United States Fish and Wildlife Service |
| ISD | Integrated Supplemental Database | USEPA | United States Environmental Protection |
| ISEP | Ion Separator | | Agency |
| ITIR | Informal Technical Information Report | UST | Underground Storage Tank |
| JPL | Jet Propulsion Laboratory | UXO | Unexploded Ordnance |
| U. 1. | oct Propulsion Eurorutory | VOC | Volatile Organic Compound |
| | | . 00 | . Jame Organic Compound |



The goal of the Installation Restoration Program (IRP) is to protect human health and the environment by finding and reducing risk. The Project Management goals are to reduce risk to the point of securing site closures as quickly as possible and with the wisest use of and highest return on program resources. The Edwards AFB IRP is achieving its environmental and project management goals. As of December 1999, Edwards AFB has closed 265 sites and devotes 46% of its budget to continuing and new removal actions that drive toward site closure. It is estimated that the Edwards AFB IRP has saved or avoided costs totalling \$83.3 million. How did Edwards AFB achieve these milestones?

Edwards AFB's strategies are that a thorough understanding of CERCLA leads to shared understanding; understanding coupled with honest, open communication builds trust and teamwork; and teamwork leads directly to progress. We use these strategies within a framework for problem solving and a commitment to make wise use of our resources.

This Investment Report briefly describes EMR's program and our **87 initiatives**, innovations, and strategies, which are built on answering these Restoration questions:

"What is the best way to approach a Restoration Program?" Programmatically. Programmatic decisions and documents that can be applied to dozens of sites pay for themselves many times over. Chapter 3 describes our twenty-four programmatic decisions, documents, and innovations, which we estimate have saved or avoided costs of \$71 million.

"What are the best possible ways to investigate soil and groundwater?" We begin with well-thought-through Data Quality Objectives (DQOs). DQOs can make or break a program. Chapter 4 explains that our investigation methods "hierarchy" uses new and old techniques, creatively applied within a framework of problem solving. Innovative investigation methods, like downhole video, have saved us \$1.95 million.

"What are the most effective ways to manage data to make the data yield the maximum information and the highest return?" Chapter 5 describes the few, well-designed databases and the creative techniques we use to get the most out of our data.

"What are the most effective ways to reduce risk?" We have tested new technologies with great success. Other techniques come from a thorough understanding of CERCLA; for example, Long-Term Monitoring is an under-used technique for managing risk. Chapter 6 describes more techniques and our \$10.1 million in savings.

"What are the best possible ways to keep our citizens informed and involved?" We depend on our Community Involvement program to inform us of our communities' concerns. Our Restoration Advisory Board is an invaluable asset to our program and has helped us save \$287,000. We share trust and cooperation with our RAB and our RPMs. We show our communities and our RAB how much we depend on them with our information sharing and training programs described in Chapter 7.

Chapter 8 describes the effect of the Edwards AFB IRP on our local economy.

CHAPTER 1

INTRODUCTION TO EDWARDS AIR FORCE BASE AND ITS INSTALLATION RESTORATION PROGRAM

Edwards Air Force Base (AFB) was originally established in 1933 as Muroc Army Air Field and now occupies 470 square miles of high desert plains and mountains in the Mojave Desert. Edwards AFB is the home of the Air Force Flight Test Center (AFFTC), the Air Force Research Laboratory (AFRL), the National Aeronautics and Space Administration (NASA), and many other tenant organizations. The Base is primarily involved in aircraft research, development, and testing. More information on Edwards AFB can be found on the Internet.

Over 460 Sites and Areas of Concern (AOCs) have been identified on the Base. Edwards AFB was placed on the National Priorities List (NPL) in 1990. As of December 1999, over 460 Sites and Areas of Concern (AOCs) have been identified on the Base. Risks posed from all

Sites/AOCs are managed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and are managed to completion in accordance with the Federal Facility Agreement (FFA). CERCLA requirements for Edwards AFB are

AFFTC Mission Statement

The Air Force Flight Test Center (AFFTC) is charged with supporting the Air Force Materiel Command (AFMC) mission by conducting and supporting research, development, test and evaluation of both manned and unmanned aerospace vehicles. This mission involves not only all aspects of testing of aerospace vehicles, but includes the flight evaluation and recovery of research vehicles, development testing of aerodynamic decelerators, and the operation of the United States Air Force Test Pilot School. To support this testing, the AFFTC operates and manages the Edwards Flight Test Range. The Center operates a fleet of test bed aircraft for early development and check out of new avionics, and Advanced Range Instrumentation Aircraft (ARIA) worldwide in support of a variety of space and missile tests. The Center supports and participates in test and evaluation programs for the Air Force, other Department of Defense activities, other government agencies, as well as for contractors and foreign governments.

implemented through four Remedial Project Managers (RPMs), representing the United States Environmental Protection Agency (USEPA), the California Environmental Protection Agency–Department of Toxic Substances Control (DTSC), the California Regional Water Quality Control Board (RWQCB)–Lahontan Region, and the United States Air Force. In addition, the Kern County Environmental Health Services Department (KCEHSD) serves as the local enforcement agency for many of our Applicable or

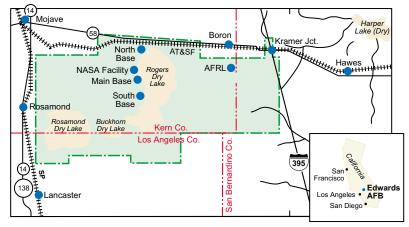


Figure 1-1. Location of Edwards Air Force Base

AFRL Mission Statement

The Air Force Research Laboratory—Propulsion Directorate is the development center for all Air Force rocket and missile propulsion technologies including propellants, combustion, characterization of exhaust plumes, and materials and structures unique to rocket propulsion. The technological development of propulsion systems includes solid propellant rocket motors and liquid propellant fuel systems and engines.



Mission Elements

- Conduct aeronautical flight research in support of global civil aviation, revolutionary technology leaps and, access to space
- Support development and operations of the Space Shuttle and future access-to-space vehicles
- · Conduct airborne science mission and flight operations
- Develop piloted and uninhabited aircraft testbeds for research and science missions

Relevant and Appropriate Requirements (ARARs). The Air Force's Installation Restoration Program (IRP), through the Environmental Restoration Division (EMR), manages the CERCLA program.

EMR's goal is to reduce the risk to human health and the environment posed by contamination and releases at hazardous waste sites. Several characteristics of Edwards AFB make its IRP unique among Air Force bases. These characteristics are the large size of the

Base (470 square

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With the proposition of the square proposition and with the proposition proposition and releases at hazardous waste sites. Several characteristics of Edwards AFB make its IRP unique among Air Force bases. These characteristics are the large size of the Base (470 square

miles), the large number of sites (469 Sites/AOCs), the extreme temperatures, the large on-base residential population, and the many flight test, rocket engine, and rocket fuel research missions.

To manage this large program efficiently, Edwards AFB RPMs and EMR have organized the Base into ten Operable Units (OUs). The OUs are primarily arranged geographically where common sources, similar pathways, and receptors exist. Chapter 2 presents a complete description of the negotiated cleanup strategies adopted by the Edwards AFB RPMs for these OUs.

EMR manages 469 Sites/AOCs. As of December 1999, we have **closed 265 sites** under No Further Investigation (NFI) or No Further Remedial Action Planned (NFRAP). Of the remaining 204 Sites/AOCs, 36 sites are in active cleanup or are awaiting the Record of Decision (ROD), one is already in Long-Term Monitoring (LTM), 159 are under investigation, and the remaining eight sites have not been assigned. We publish an updated status in our widely-distributed Monthly Status Report (MSR).

We will issue our Draft ROD on 6 July 2004. Removal actions will continue through the year 2014 with a few sites remaining in LTM after that date.

This report contains brief descriptions of 87 of our initiatives and innovations that have been the keys to our success.

We estimate that the Lessons
Learned described here have saved or avoided costs

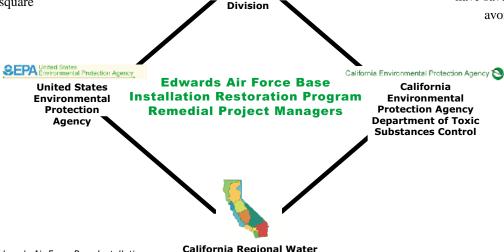


Figure 1-2. Edwards Air Force Base Installation Restoration Program Remedial Project Managers

California Regional Water Quality Control Board -Lahontan Region

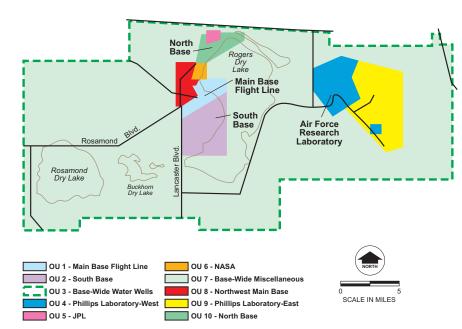


Figure 1-3. Edwards Air Force Base Operable Unit Number and Description

of **\$83.3 million.** Our strategies and initiatives are described in these chapters:

Chapter 2: Edwards AFB's Step-wise Cleanup Strategy

Chapter 3: Twenty-Four Programmatic Investments

Chapter 4: Innovative Investigation Techniques

Chapter 5: Turning Data into Information

Chapter 6: Cleanup and Risk Reduction Methods

Chapter 7: Community Involvement Initiatives

Chapter 8: Advantages to the Local Economy.

The federal and state RPMs and the other federal, state, and local regulatory representatives who oversee

EMR's goal is to reduce the risk of contamination to human health and the environment.

our efforts are pleased with the achievements and progress of the Edwards AFB IRP. The Restoration Advisory Board (RAB) representatives are satisfied that community concerns have been incorporated

in the prioritization of IRP investigations and selection of IRP cleanup technologies.

PURPOSE OF THE DOCUMENT

Over time, Congressional programs, priorities, technologies, requirements, budgets, decision makers, and community concerns change. Moreover, the Edwards AFB IRP is a very large program with a lot of activity going on all the time. Questions about Restoration Program strategies, objectives, and methods are frequently asked by people who are new to the Base and to the Antelope Valley.

The Management

Action Plan (MAP), the EMR Business Plan, and the Comprehensive Remedial Investigation/Feasibility Study (RI/FS) Management Plan present important facts about the Edwards

AFB IRP and how its performance is measured. But these plans were never intended to address in a simple way the most frequently asked questions about how the Base is being cleaned up, or to present a coherent overview of the strategies used to drive the

The Investment Report describes the methods used by Edwards AFB to accomplish our site cleanups.

IRP. The purpose of this document is to simply and concisely answer the frequently asked questions, among them, "How do you accomplish these cleanups? How did you get this far? How will you go forward from here?" We prepared this document to fill in the blanks and provide the rest of the story not covered by the MAP and the EMR Business Plan.

EDWARDS AFB'S STRATEGIES AND APPROACH

Without a strategy and framework that drive toward problem solving, Restoration Programs can become lengthy routines of data collection, reporting, and

debating, without much progress. Over the long life of a restoration program, everything changes—the priorities, requirements, budgets, technologies, and agency personnel. Some strategies and approaches will hold up well over time and will give a high return on investment, while some approaches won't hold up as well.

The RPMs and the local community regard the Edwards AFB IRP as a successful program. Edwards AFB's strategies and approach have generated this success. Edwards AFB's strategies are that a thorough understanding of CERCLA authority leads to shared understanding, understanding coupled with openness and honesty fosters team building, and team building leads directly to progress. Here are the strategies and problem-solving methods that have been central to our progress at Edwards AFB.

1. We understand our authority. A detailed and accurate understanding of CERCLA and its authority is the cornerstone of the Edwards AFB IRP. We understand completely all of our authorities as lead agency. We understand the limits on our authority and use all the power and tools vested in being the lead agency. When we say we

Understanding CERCLA and our authority as lead agency is a cornerstone of the Edwards AFB IRP. will do something, we know we have the authority and resources to actually do it and follow through.

Furthermore, the Federal Facility Agreement (FFA) allows for changes in the schedule and procedures with the concurrence of all four signatories. It is through the interpretation of these

provisions that EMR can find the flexibility that leads to program advances and progress.

Because the Base RPM and the EMR Project Managers (PMs) have a thorough and accurate understanding of their authority as the lead agency, the PMs can be open and relaxed when listening to other people's concerns and suggestions. PMs are open to adding ideas and techniques that they are not required to use, but which they will gladly try if the technique looks like it will work or looks like it deserves to be tested.

2. We demonstrate honesty and openness; a promise made about how we will do business is a promise kept. We openly ask for advice and counsel. We listen to the experiences of others, including the RPMs, members of the RAB, employees, residents, and the community, and we

We show a willingness to allow open participation with regulatory agencies and use the best of what everyone has to offer.

promise cooperation and a participatory climate. We generally accept and will try a technique that an RPM wants tested if the technique satisfies EMR's overall investigation strategy; namely, that the data already support the action, or Data Quality Objectives (DQOs) can be generated, and the technique can be performed safely. With regulatory agencies, we show a willingness to allow open participation, and we use the best of what everyone has to offer. Suggestions are seriously considered and adopted wherever feasible. If we can't follow through on an action, we immediately call a meeting or teleconference and explain why we can't, and suggest something we can do.

3. We demonstrate our belief in team building.

Everyone who discusses his or her ideas and concerns with us becomes a team member, a full participant in the cleanup. We won't allow lines to be drawn between "them" and "us."

Our promise of teamwork can be expressed very simply. We inform everyone openly, honestly, and often. Everyone will be told what we are doing. Everyone can watch what we're doing, either directly or through

presentations at RAB meetings. Everyone can comment on our efforts and make suggestions. We will publish our results, everyone's comments, and our next

We inform everyone openly, honestly, and often.

steps that result from the discussions.

Open and honest communications have tremendously benefited the trust and teamwork

Introduction to Edwards Air Force Base and Its Installation Restoration Program

shown to us by our RPMs and other regulatory agencies. Team building includes active participation with the regulatory agencies. We understand that we must follow regulations properly and build consensus among the RPMs and other regulatory agencies about the activities we undertake. We are ultimately responsible for the safe restoration of Edwards AFB's hazardous waste sites and we openly and actively seek advice and counsel.

The internal EMR team and Air Force teamwork are important too. We rely heavily on corporate teamwork and corporate memory to make us more efficient and more effective.

4. We use funds wisely. Wise use of funds is a requirement to receiving more funds. Therefore, we will spend money to test technologies or innovations where we can reasonably predict there

We spend money to test technologies or innovations that will accomplish our objectives. will be a return on the investment. The rule at Edwards AFB is "Just because you can try a thing doesn't mean you should." Funds will be invested in technologies and equipment after considering the total

lifecycle cost of ownership and the likelihood that the technology will be at least partially effective.

And it is not just IRP resources that we are protective of; we are protective of other Air Force resources as well. Edwards AFB is a large and complex base containing multiple tenants performing a variety of functions 24 hours per day. The environmental restoration activities represent one small aspect; however, our actions can significantly affect other Air Force and tenant activities and resources. Close coordination of our efforts with others saves everyone time and money.

5. We are biased towards risk reduction, not further study. We investigate Sites and AOCs and determine if further investigation is warranted. Well-planned DQOs ensure that we collect the right data in the right amounts for the right reason. Our smart DQOs mean our investigations conclude very quickly, and we have the right data to make a risk reduction decision.

We act quickly to remove the source of contamination. Then groundwater models and other tools tell us where risk remains. We reduce risk quickly using streamlined CERCLA processes, including Interim Removal Actions.

Using the streamlined CERCLA process, we press ahead to begin risk reduction. We have seen a large return on our investments in Engineering Evaluation/Cost Analyses (EE/CAs) and Interim Removal Actions (IRAs), as well as in Treatability Studies using new, innovative, or emerging technologies.

6. We use technology smartly. We are very familiar with the whole gamut of presumptive remedies, off-the-shelf methods, innovative techniques, and equipment and procedures being field tested for the first time. We are not hesitant about joining

different techniques together to solve a sitespecific problem. If it doesn't appear to work, we'll take it apart, add new techniques, and reengineer it to make it work.

We join different techniques together to solve a sitespecific problem.

We do not stifle initiative or creativity in technology applications. Edwards AFB is a flight TEST base, and we take that mission seriously in the IRP as well. Edwards AFB's contamination will not leave Air Force property or harm others. We invite and encourage others to practice and refine their cleanup technologies on our sites.

7. We work invisibly. EMR operates the IRP in such a manner that the site customer is generally unaware that the investigation and cleanup processes are occurring. Done properly, the entire investigation and cleanup program is planned with the full awareness and concurrence of the customer, and executed so as to be invisible to the customer and the customer's mission. When done well, the

Our framework for problem solving has yielded dozens of advances in investigation and risk reduction. IRP gains the respect and support of the customer. EMR's customers have been heard to say "We are cleaning up our own backyard with EMR's help."

Since 1990, these strategies and framework

for problem solving have yielded dozens of breakthroughs and advances in investigation and risk reduction. Chapters 3 through 8 describe 87 of our achievements, innovations, and initiatives. The description of each initiative is intentionally brief. It has been prepared to provide the reader with a quick overview of how the technique is applied, when it was initially tried, the benefits the program gained from using it, and how the techniques have been a wise use of Restoration resources.

When funds are tight, as they are now, every decision is more critical and therefore harder to make. We saw, early in our program, that we would have to find new initiatives and breakthroughs in order to succeed. The benefit of our approach is that Edwards AFB has already made most of the hard decisions. Edwards AFB exemplifies the expression: "The point of the IRP is not to start, but to finish."

CHAPTER 2

EDWARDS AFB's SIMPLE, STEP-WISE CLEANUP STRATEGY

The goal of the Edwards AFB IRP is to protect human health and the environment. The Base is accomplishing this goal through the following interrelated steps which constitute the Base cleanup strategy. There is more than one strategy being used to accomplish the cleanup goal; individual site and operable unit specific strategies are discussed in the Management Action Plan. This chapter describes the overall base cleanup strategy:

- 1. Locate and stop all discharges.
- 2. Find all locations where hazardous waste or

hazardous materials were released.

- 3. Determine the relative risk each release causes in water, soil, and air.
- 4. Close off access to all contamination.

EMR locates and assists Base users with completing actions on all hazardous waste sources.

- 5. Investigate and manage all release sites until they pose no risk.
- 6. Reduce risk with Interim Removal Action (IRA).
- 7. Prepare a single, base-wide Record of Decision (ROD).
- 8. Implement ROD-approved actions.

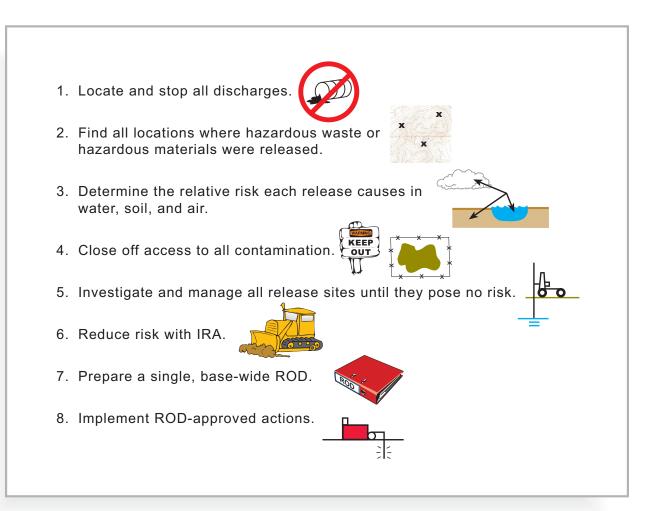


Figure 2-1. Edwards Air Force Base Overall Cleanup Strategy

The steps in more detail are:

1. Locate and stop all discharges of hazardous materials and wastes into the environment.

Technically this step is not part of the IRP. However, cleanup systems are designed to treat contamination of known concentrations and areal extent. Models developed to predict the behavior of contamination assume that there are no continuing sources. It is foolish to design and construct a cleanup system for an aquifer or volume of soil that continues to be contaminated. For this reason the IRP continues to locate and cause to be corrected all hazardous material and waste sources.

- 2. Identify and document all locations where hazardous materials and wastes have been released into the environment. This step was first completed with the conclusion of the Expanded Source Investigation/RCRA Facility Assessment (ESI/RFA). Additional Sites/AOCs have been added to the program through archival research efforts, through remote sensing of the range, and through interviews with past employees. The initial Preliminary Assessment/Site Inspection (PA/SI) effort has been completed and no further PA/SI funding is being requested. However, if previously unknown release sites are identified through information generated by the above on-going efforts, they will be added to the IRP and prioritized for further investigation.
- **3.** Determine the relative risk each release has on the surface water, groundwater, soil, and air. The relative risk calculation considers:
- The geographic location;
- Toxicity of the material released;
- Its mobility in the soil, air, and groundwater;
- The potential impact the release may have on drinking water sources, on accidental contact to visitors, dependents, and base employees; and
- Impacts to base infrastructure and buildings.

The relative risk also considers the potential impact the release may have on the plants, animals, and unique natural resources of the Base.

4. *Prevent access to contamination.* Institutional controls are used where direct or inadvertent access to released hazardous materials or wastes is possible. Institutional controls include land use constraints,

control over digging and surface access, fencing, signs, electronic surveillance, worker education, and monitoring of the contamination. Initial actions taken to prevent access to the contamination are not considered to be the final cleanup remedy, but are

Areas having the greatest relative risk are given higher priority for investigation and cleanup if warranted.

an IRA taken to reduce human health risks by limiting human contact with the contamination.

- 5. Investigate and manage all hazardous waste release sites until they pose no risk to human health and the environment. There are hundreds of Sites/AOCs on the Base. Each one will be investigated, monitored, and managed in accordance with the FFA until it poses no risk to human health or the environment. Information about each site's contamination and history is documented in individual site summary reports. The Base uses several methods to manage hazardous waste release sites. Each method is described in more detail in the following subsections.
- a. No Further Investigation (NFI) With Unrestricted Land Use. When the Base is confident that the extent of contamination is known and the concentration and toxicity of the release is below action levels, an NFI report is prepared. This document presents the data supporting the conclusion that no further investigation, institutional controls, or cleanup is required at this site. The Base allows unrestricted land use on the site. Because neither the Base nor the regulatory agencies can declare the site to be closed until it is included in a final ROD, the NFI is used to obtain concurrence that, as of the date of the NFI, the site contained no contamination above an action level and unrestricted use was protective of human health and the environment.

All signatories to the NFI understand that any of the following can change: the action levels, the understanding of the toxicity of the contaminants, and the techniques for investigating and characterizing the contamination. Any of these changes could require the Base to reexamine the NFI decision and possibly require restrictions to the land use, further investigation of the contamination, and possibly the installation of a cleanup system as a condition of the ROD.

b. No Further Investigation (NFI) With Restricted Land Use. There are conditions where the Base may prepare an NFI knowing that contamination exists above an action level. This can occur when the extent of contamination is known, and the concentration or toxicity of the release is above action levels but does not pose an acute risk to human health or the environment if it were accidentally contacted. An NFI might also be prepared if the contamination was absent from the soil but above an action level in the groundwater.

The NFI is prepared if the Base is confident that it can use institutional controls to manage the risk by preventing contact with the contamination. This document presents the data supporting the conclusion that no further investigation or cleanup is required at this site as long as restricted land use can be achieved. The Base allows restricted land uses on the site and

There are conditions where the Base may prepare an NFI knowing that contamination exists above an action level.

denies access to the contaminated soil and/or groundwater without a written workplan that assures protection of human health and the environment. Because neither the Base nor the regulatory agencies can declare the site to be closed until it is included in a final ROD, the NFI is used to

obtain concurrence that, as of the date of the NFI, the site contained some contamination above an action level and restricted use was protective of human health and the environment.

All signatories to the NFI understand that any of the following can change: the action levels, the understanding of the toxicity of the contaminants, and the techniques for investigating and characterizing the contamination. Any of these changes could require the Base to reexamine the NFI decision and possibly require increased restrictions to the land use, further investigation of the contamination and possibly the installation of a cleanup system as a condition of the ROD.

c. Reduce The Toxicity, Concentration, And Mobility Of The Contamination. Releases of hazardous materials and wastes above an action level require further investigation and either cleanup or control. The reduction in the toxicity, concentration, and mobility of the contamination is accomplished through the implementation of an IRA.

An IRA can be as simple as excavating the contaminated soil and treating it in a soil farm or it

can be the installation of a complex system that simultaneously treats the soil vapors and the groundwater. Generally IRAs utilize proven, off-the-shelf cleanup equipment. Soil vapor extraction, bioventing, soil removal, dual extraction, groundwater treatment,

IRAs are used to reduce contamination quickly.

bioslurping, and in-well vapor stripping are just some of the techniques used to reduce the areas of greatest contamination.

The details of how an IRA will function are described in an EE/CA. Resolution of any comments made by the public and the regulatory agencies is described in the Action Memoranda where the Base declares its intent to implement the IRA. Generally the goal of the IRA is to remove as much of the source of the contamination as possible within a limited area. By focusing on reducing the concentration of the most contaminated areas, considered by the Base to be "hot spot removal" (hot spots are areas of greatest mass of contamination, acting as a source

contributing to groundwater contamination), the physical and microbial natural attenuation processes will have a greater effect. The acute human health and ecological consequences of accidentally coming into contact with the remaining contamination will be reduced through the IRA

Generally the goal of the IRA is to remove as much of the source of the contamination as possible within a limited area.

process. The implementation of an IRA also gathers cost and performance data that will be used to support the determination of the final cleanup remedy.

d. Long-Term Monitoring (LTM) Of The Contamination. When suggesting the use of LTM, the Base recognizes that placing a site in LTM has not reduced the volume and toxicity of the contamination

The Base will generally suggest LTM when the costs and health risks from a cleanup are unacceptable.

in the area, but believes that the implementation of institutional controls will reduce the risk to human health to acceptable levels by controlling access. There are several situations where it may be preferable to not initiate cleanup, or to cease active cleanup operations, before

contaminant concentrations have been reduced to below action levels. In these situations the Base will suggest that the site be placed into an LTM phase.

Long-Term Monitoring of contamination is best used on sites where the contamination is stable or naturally degrading or too dangerous to remove, where the areal extent and rate of migration of the contamination are known and can be accurately monitored, and where accidental contact with the hazardous waste can be controlled with institutional controls. The Base will generally suggest the use of LTM when the costs and health risks associated with a cleanup are unacceptable, such as when excavating a landfill.

The Base may also suggest the use of LTM to manage risk when the damage to the natural resources caused by the investigation and cleanup would be excessive and unacceptable to the Natural Resource Trustees. The LTM designation requires the Base to permanently monitor the toxicity and extent of the contamination until it naturally degrades or until the Base decides to install and operate a cleanup system. e. Long-Term Operation (LTO) Of Interim Removal Action Cleanup Equipment. During the time that cleanup equipment is in operation to reduce the concentration and migration of contamination the site is in an LTO phase. This phase continues until contaminant concentrations at the site have been

reduced to an acceptable level, but not necessarily to Maximum Contaminant Levels (MCLs). This acceptable level of concentration will be defined in the ROD. Before signing the ROD, the Base may place a site in LTO during the

operation of an IRA.

The final cleanup levels that an IRA are expected to reach are not included in a ROD. The decision to change the method of operation or to cease operations all together on an IRA is made by the Base

The LTO phase reduces the concentration and migration of contamination.

with the advice of the regulatory agencies. If the contamination in the site has not been reduced below action levels when the IRA is concluded, the site will transition from LTO to LTM.

f. Operation And Maintenance Of Cleanup Equipment. The Base and the regulatory agencies agree to a final cleanup remedy and cleanup level in the ROD. Cleanup actions taken pursuant to the ROD are called remedial actions rather than removal actions. It is anticipated that most of the IRAs taken by the Base before signing the ROD will be considered the final

cleanup remedy and will be designated as remedial actions. Some sites may require that a new remedial action be undertaken. Remedial action cleanup equipment will be operated and maintained until the

Most IRAs will be considered the final cleanup remedies.

cleanup level approved in the ROD is achieved.

6. Reduce the risk to human health and the environment with IRAs. Prior to preparing the basewide ROD, the Base will investigate Sites/AOCs, determine if further investigation is warranted, apply institutional controls on sites where contamination exceeds action levels and design and install IRAs to reduce the concentration of contamination at each site. If economically and technically practicable, the Base will institute an IRA that may be the final cleanup remedy that will reduce contamination to below action levels. Where this is not possible, the Base will operate the IRA until the risk to human health and the

environment is significantly reduced. The site will continue to be monitored to determine if natural attenuation processes are degrading the contamination and to provide assurance that the contamination is not migrating faster than anticipated. This does not preclude implementing other treatment methods if warranted.

7. Prepare a single base-wide ROD detailing the actions the Base will take to protect human health and the environment. The base-wide ROD will reference the ESI/RFA, NFIs, site summary reports, the Remedial Investigation and Feasibility Study for Operable Unit 1, treatability studies, EE/CAs and Action Memoranda, data collected for the sites in LTO and LTM, and the base-wide human Health Risk

A single, base-wide HRA, ERA, and ROD will be prepared. Assessment (HRA) and focused Ecological Risk Assessment (ERA). If the IRAs and institutional controls have accomplished their objectives, the base-wide ROD will document the

site closures for the majority of the hazardous waste release sites, establish the level of institutional control needed to protect human health and the environment on those sites in LTM, establish the cleanup levels for those sites that are in LTO, and will transition either to site closure or to LTM with institutional controls.

A base-wide human HRA, estimating the individual and cumulative human health risk posed by the remaining contamination will be prepared. The damage to the natural resources caused by the contamination and by leaving some contamination in the soil, groundwater, and air will be assessed in a focused ERA. This risk assessment will be conducted on sites where there is an identified pathway to plants and animals. The acceptable level of risk to the ecological receptors will be determined by the Base in consultation with the Natural Resource Trustees.

The results of the human HRA and the focused ERA will assist the Base and the regulatory agencies in determining if the results of the IRAs have been sufficient to allow unrestricted use of the land, restricted use with institutional controls and LTM, or if additional cleanup actions are required to protect human health and the environment.

The results of the feasibility and treatability studies and the operational data will be used to determine if it is technically and economically practicable to construct and operate additional cleanup actions on the sites determined by the human HRA or ERA to require further review. If the concentration of contamination cannot be reduced to below action levels within a reasonable period of time, or without excessive cost, or without causing unacceptable amounts of damage to the natural resources, the Base will suggest that institutional controls be used to protect human health. This decision would be made after consulting with the public and the regulatory agencies, and after considering the Applicable or Relevant and Appropriate Regulations (ARARs). For each site with contamination above the action level, the proposed action that is protective of human health and the environment is cost effective, is technically feasible, and is protective of the natural resources will be presented to the regulatory agencies and the public as the Proposed Plan. The comments from the public and the regulatory agencies will be considered when preparing the ROD.

8. *Implement ROD approved actions.* CERCLA requires that cleanup actions begin no later than 15 months after the approval of the ROD. Any sites that were unable to be funded for an IRA prior to the ROD will be funded in the following fiscal year (pending approval of the budget by the Congress) for a remedial action design followed by a remedial action.

CHAPTER 3

TWENTY-FOUR PROGRAMMATIC INVESTMENTS

Within a framework of early risk reduction and wise use of resources, and with a goal of maximum site closures, what is the best way to approach the restoration of over 460 IRP Sites/AOCs?

Programmatically.

- Frame the early questions and answers so that they apply to as many sites and investigations as possible.
- Conduct the early investigations to gather as much information as possible for "lessons learned" on how to conduct the same studies more efficiently on other sites.

Programmatic investments pay for themselves many times over.

Examine risk assessment res

 Examine risk assessment results critically to see which results are true for the rest of the Base.
 Which results can be used to screen other sites and to start early action and early risk reduction? An investment in a programmatic study pays for itself many times

In this chapter, we present the results of EMR's twenty-four

\$10 Million Saved by the 1992 Base-wide ESI/RFA

programmatic investments to date. By conservative estimate, these investments have saved the program \$71 million.

INTEGRATE RCRA AND CERCLA PROGRAMS

In 1990, immediately after being listed on the National Priorities List (NPL), EMR began its basewide Expanded Source Investigation/RCRA Facility Assessment (ESI/RFA). The three-year effort resulted in the seven-volume ESI/RFA document, which was completed in 1992. We also completed our first Remedial Investigation (RI) in April 1996.

In the years since 1992, we estimate that we have **saved probably \$10 million** by having conducted the ESI/RFA for the entire Base at one time, though it seemed an impossibly large task at the time.

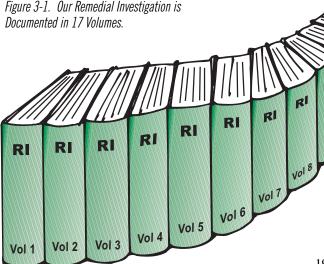
There have been two huge advantages from the 1992 ESI/RFA:

1992 that the 1,040 original Sites, AOCs, Potential Release Locations (PRLs), and Solid Waste Management Units (SWMUs) could be reduced to the roughly 469 Sites/AOCs needing further investigation; and

• The RPMs agreed in

• By knowing how to proceed from the ESI/RFA to integrating the Sites directly into the CERCLA process, hundreds of RCRA sites have been closed, not to background concentrations, but under CERCLA and according to the *risk* they pose.

All this was accomplished at Edwards AFB in 1992. Today some bases are being interrupted in their



IRP cleanups and RCRA permitting activities to stop and conduct their inventories of RCRA SWMUs. The delay to study RCRA SWMUs brings with it several other serious disadvantages:

- The Air Force is short of funds for studies, and the budget will not increase;
- Congress and the American people believe RCRA studies should have been finished by now;
- Regulatory agencies do not always support converting SWMUs to CERCLA sites if that groundwork was not laid long ago;
- RCRA efforts that are beginning now are under the jurisdiction of the RCRA side of state agencies, not the CERCLA side, which brings new players, new procedures, and tremendous inefficiency to the IRP; and
- RCRA's and CERCLA's cleanup requirements often conflict with each other, and that can confuse project managers, regulatory agencies, RAB

members, and our communities.

EMR avoided having both RCRA and CERCLA in force on different cleanups at the same time by fully using the FFA to integrate RCRA and CERCLA. RCRA is one of the

IRP's ARARs, meaning RCRA is not ignored, but CERCLA prevails over RCRA, and RCRA is used as a supplemental

guidance. By taking the long view and installing this feature in the FFA, the Air Force avoided confusion and disagreement among the RPMs, our communities, and our other stakeholders over competing regulatory requirements.

Edwards AFB

avoided having

both RCRA and

CERCLA in force

simultaneously.

LESSON LEARNED: CERCLA DOES NOT SCALE UP WELL

CERCLA's numerous steps and studies were developed to address the localized risks presented by a hazardous waste "dump" or an illegal drum disposal yard. When we saw the time, expense, and

unwieldiness of the documents that resulted from strictly applying CERCLA to only the 38 sites in OU1, we knew we had to make a change. The HRA also did not prove very useful; it proved only that concentrations, which can already be seen to be above MCLs, are health risks. That fact is self

Conventional
CERCLA documentation is unwieldy.
SACM and Lead
Agency authority
saves millions of
dollars.

evident. Moreover, the OU-wide risk assessments made it no easier to understand the individual or cumulative risks posed by each contaminant or site.

We investigated the legalities and authorities within CERCLA to see how it could be applied more sensibly. We found that by understanding our authority as lead agency and the principles of the Superfund Accelerated Cleanup Model (SACM), we could proceed from the RI directly into streamlined, accelerated CERCLA processes: Treatability Studies (TS) and IRAs based on EE/CAs, in place of huge RI/FSs. We can close sites based on findings of NFI or NFRAP. Following a TS, we can recommend proceeding directly into LTM to monitor the decrease in residual risk. We have saved tens of millions of



Figure 3-2. Dual Extraction System Interim Removal Action at Site 45

dollars by not following the original strict order of CERCLA steps and documents, and by sensibly applying a knowledge of CERCLA and the authority it grants us.

SACM gave us the guidance to rearrange in CERCLA what others previously took to be inviolate and unchangeable. Edwards AFB has taken maximum advantage of CERCLA's flexibility and has used its authority to forge even more changes with the RPMs. We looked closely at the SACM models used by USEPA, borrowed the cost-effective steps that allowed early risk reduction, and adopted a process with which our stakeholders were comfortable.

We began using non-time-critical, time-critical, and, if required, emergency Removal Actions. We began writing shorter, ten-page EE/CAs that made reference to longer documents.

SACM also showed us methods for incremental risk reduction:

- First fence off the site to immediately lower risk by denying access;
- Study the site to see if more risk reduction or cleanup is required; and
- Use institutional controls as a partial remedy at each step of the investigation and cleanup.

Finally, we reviewed the OU1 HRA to see if we could use it programmatically and found that having it benefited the program in two ways: it established the modest range of risks in OU1 which, containing the flight line and industrial complex, is the location on base where there would likely be the most risk to human health. This allowed us to know how to describe the range of risks across the Base to our residents and stakeholders. The HRA also established the approved methods and calculations that would be used to calculate human health risk anywhere on the Base.

PRIORITIZE OUS USING RISK TO RESIDENTS AND EMPLOYEES

In what order do you apply resources and conduct the cleanup of over 460 Sites/AOCs? By developing priorities based on the risk to the people who live and work there.

Edwards AFB is large—about 470 square miles—so in 1990, we began with not one but seven OUs, generally arranged geographically around common sources and receptors. But we still needed a way to prioritize our investigations,

We prioritized the OUs according to the risk to the human population.

assign resources, and begin risk reduction. We discussed prioritization with employees and the surrounding communities, and we listened to their concerns. We prioritized the OUs according to the risk to the human population, roughly combining these factors:

- The size of the population;
- Whether the population was resident round-theclock or was resident for eight hours; and
- How many years that part of the Base had been occupied and hazardous materials would have been in use.

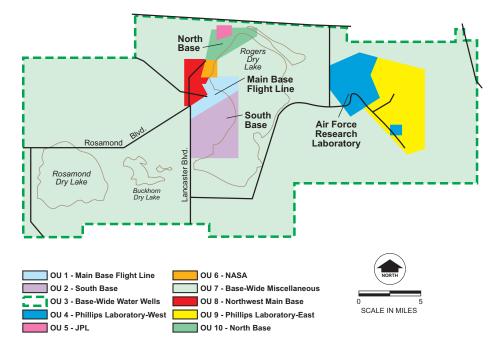


Figure 3-3. Edwards Air Force Base Operable Unit Number and Description

These factors led to these priorities:

- OU1 the large Main Base employee population;
- OU2 the smaller South Base employee population;
- OU3 over 700 former homestead wells that provided open access to our groundwater supplies;
- OU4 the occupied portions of AFRL;
- OU5 the Jet Propulsion Laboratory (JPL); and
- OU6 National Aeronautics and Space Administration (NASA)-Dryden Flight Research Laboratory.

The last of the early OUs, OU7, covered base-wide miscellaneous sites.

The original OU1 proved too large and its size prohibited us from beginning early action. We had sufficient data to begin the RI of *parts* of OU1, but, large as it was, we would have to wait years for more data on the rest of the OU before beginning the RI. We split OU8 out of OU1 and began the RI of the now smaller OU1. We similarly split the unoccupied portions of the AFRL, OU9, out of OU4. That left only an employee population at North Base that was not covered by an OU. We expanded the borders of OU5 to encompass those employees and left the unpopulated land as OU10. Now we could apply resources over smaller land masses and move to reduce risk more quickly.

PROGRAMMATIC NATIONAL ENVIRONMENTAL POLICY ACT DOCUMENTATION IN 1991, REQUIRES BEST MANAGEMENT PRACTICES

CERCLA procedures satisfy the resource protection and conservation requirements of the National Environmental Policy Act (NEPA), but in 1991, Air Staff did not yet agree with that, so it was necessary to conduct NEPA Environmental Assessments (EAs) at each IRP site. Edwards AFB would be faced with major delays if EM office staff sought to provide EA decisions and mitigations on dozens of sites at a time.

A solution was needed. EMR developed a method for conducting a Programmatic EA for the entire IRP despite not knowing what the investigation and cleanup methods and their impacts would be at each site. Our analysis of the impacts caused by the worst case alternative for each site supported a Finding of No Significant Impact (FONSI). We used the recommended mitigations from the EA as Best Management Practices for all investigations and removal actions. Following these Best Management Practices allows our staff and contractors to access the sites and still protect habitats and cultural resources to the greatest extent practicable.

We also conducted global cultural resource surveys on all OUs. Using those results, we dismissed most cultural resource impacts. We continue to minimize the remaining impacts using surveys early in the IRP process to clear particular sites.

The benefits? Many.

- The environment is protected by our use of Best Management Practices;
- We are not tied up working only on clearing IRP sites; and
- Drilling crews of five to seven people and three trucks do not have to delay, waiting for site clearance.

The result? Less time spent, fewer steps, lower cost, and Best Management Practices still employed

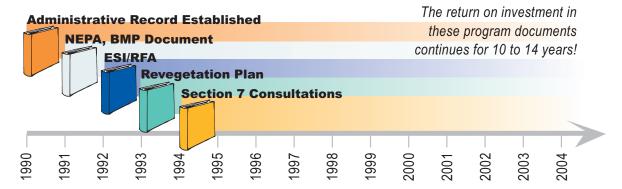


Figure 3-4. Programmatic Documents Help Most When Done Very Early in the Program.

across the board. If we have saved only eight hours per site total by EM and contract staff to obtain cultural and natural resources clearances or conduct surveys for over 460 Sites/AOCs that have been, are being, or will be investigated, we have **saved** \$187,600.

CONSISTENTLY USE TIMELY CULTURAL AND HISTORICAL SURVEYS TO CLEAR DIGGING PERMITS

Without a programmatic approach to protecting cultural resource sites throughout the Base, IRP efforts would be dramatically slowed. The old buildings and partial foundations and structures at World War II, Cold War, and Man in Space facilities are important to our understanding of what took place there during the 1940s to the 1980s. These buildings are exactly the places where hazardous materials would have been used, so there is almost a one-to-one correlation between historical sites and IRP source locations.

EMR arranged for a complete historical and cultural survey and assessment of the OU. EMR and the Base Historic Preservation Officer (BHPO) have together developed a form on which cultural resource personnel describe sites and whether monitors will be required during field activities. When IRP personnel need a digging permit, they fill out the form, entering resource information that is easily available from EMR programmatic documents. The BHPO has confidence in the programmatic documents and confidence that EMR will follow the mitigations previously agreed to.



Figure 3-5. Aerial Photo of Muroc Army Air Field

The result is no delays in the digging permit, and conflicts over resource conservation procedures versus the FFA schedule do not occur. The cooperation has allowed the unobstructed removal of more than 330 underground storage tanks (USTs), the investigation of more than 700 water wells, and access to all sites by EMR.

SEPARATE, EARLY BIOLOGICAL OPINIONS FOR OU INVESTIGATIONS

Global habitat analyses in the EA benefited the Biological Opinions and reduced the tortoise monitoring requirements. Remedial investigation field work began in 1994, and EMR started planning to avoid adverse effects on our natural resources. We began obtaining separate Section 7 Biological Opinions to ensure the protection of desert tortoise populations in each OU. Why separate

Opinions? Our OUs are large; each can be ecologically diverse within its boundaries. For example, there are many desert tortoise in OUs 4 and 9, which require maximum tortoise protection measures, including heavy monitoring.

But in our Programmatic EA, we had included global habitat analyses that showed that the OU tortoise population figures are different and not all should require monitoring. We proceeded with separate Biological Opinions for each OU, and, as a result, EMR is not required to apply heavy monitoring in every OU.

The benefits?

- With Biological Opinions in hand early in the program, we designed our procedures and systems in accordance with the Opinions;
- The Biological Opinions and mitigations are available long before we

We made sure early in the program that each OU received a separate Biological Opinion that covered the entire OU.

begin investigations in an area, meaning we and our contractors can plan more easily;

- Where monitoring is not required, we don't have to pay for a trained tortoise monitor; and
- We do not have to wait the 135-day comment period by the US Fish and Wildlife Service before beginning field work.

PROGRAMMATIC REVEGETATION PLAN IN 1993

EMR wrote its Programmatic Revegetation Plan in 1993, still early in the IRP. The Plan tells EMR where and how much vegetation to replant based on the amount of vegetation disturbed by IRP projects. However, there is a cost-saving feature in the Plan. EMR does not have to begin revegetation for a year after a project is complete. If the desert has naturally revegetated in that time, EMR does not need to act at all.



Figure 3-6. The Programmatic Revegetation Plan Tells EMR Where and How Much Vegetation to Replant Based on the Amount of Vegetation Disturbed

OU1 AS A TEST BED

Investigations began first in OU1. When it became clear that the groundwater plume under OU1 would not migrate off the Base, into an ecologically-sensitive area, or into drinking water, we saw we could use that result to benefit the other nine OUs. We test new and old technologies on our contaminants and our hydrology in OU1 first, then we export to other OUs the technologies that work well.

As of December 1999, we have tested seven technologies in OU1 first and have used five of them successfully. OUs 2 and 4 have also been test beds for new technologies.

AN EARLY PLAN FOR FILE ORGANIZATION, INFORMATION REPOSITORIES, AND FOR THE ADMINISTRATIVE RECORD

The Edwards AFB IRP program files occupy hundreds of cubic feet of file space. Years ago, EMR looked far ahead to the size and complexity of the program files, their need for organizational access, and the crucial need to eventually form the Administrative Record (AR) from the program files. EMR also wanted its files and many other materials to help the public stay informed about and involved in the IRP. How could EMR accomplish all these goals? We achieved them through smart, early planning and implementation. Here are a few details about our IRP library:

- We established our library and its resources early in the program.
- The organization and shelving system was also developed early in the program in a written Operating Instruction (OI).
- Our full-time librarian barcodes all documents and shelves them according to the written OI.
- Most documents are, of course, already available electronically. Selected older documents are scanned in as images [but not generally converted into text with Optical Character Recognition (OCR) software].

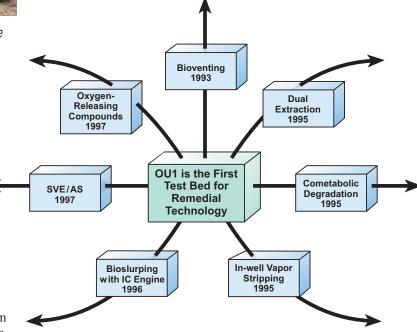


Figure 3-7. OU1 is the First Test Bed for Remedial Technologies.



Figure 3-8. The Administrative Record Library

Making these decisions early on about our file and document library and establishing the resources to accurately maintain the files has saved us from confusion and error and years of effort were we to try to organize our files now. We also

check the quality and accuracy of our filing system. We have audited our library by having "strangers" request documents; requests were filled quickly and with very few errors.

How do we solve the problem of using this large, imposing volume of information to inform and involve our communities? Our four smaller Information Repositories (IRs), both on base and off base, handle that job for us. The IRs contain all kinds of helpful materials and information to help interest the public and answer their questions:

- Technical documents that are available for public comment:
- Copies of the many fact sheets and synopses prepared by EMR to acquaint the RPMs and others with EMR's challenges and the technologies it's testing;
- · Maps and diagrams; and
- · Copies of our monthly "Report to Stakeholders."

We also make things simpler and clearer by removing documents from the Repositories when comment periods expire. This effort keeps people from becoming frustrated when their comments cannot be responded to because the comment period is closed and the document has been finalized.

We have one repository on base and three off base. The three off-base repositories are in Boron, Lancaster, and Rosamond. We make our Repositories convenient and easy to use, and we expend effort to keep them up to date. Our credibility and the IRP's progress have both benefited.

In Boron, we found the Boron library is not very large and is not open every day. We searched for and

found a space that is open more often—the local museum. It is evident that the people of Boron are pleased with that decision.

We designated which files would reside in the AR and which would not.

What else has EMR accomplished that yields a high return? Only

documents used to make a cleanup *decision* will become part of the AR in 2004. But at that time, the AR must be formed from our files. We have already made that transition easier and less time consuming; our OIs dictate which documents will be part of the AR and which will not. Knowing and using that part of CERCLA will make a difference of hundreds of cubic feet in the size of our AR and a huge difference in the taxpayer dollars needed to store and maintain it.

IRAS AND PRESUMPTIVE REMEDIES SPEED RISK REDUCTION AND SITE CLOSURE

In the nine years since 1990, the steps we take in investigation and risk reduction have become very consistent and repeatable. The RPMs are satisfied with our step-wise approach, saving us numerous steps and probably millions of dollars over the nine years, but most importantly, the steps help us achieve early risk reduction.

IRAs allow risk reduction to start quickly by avoiding the numerous studies and documents that the

RI/FS process normally requires. Using EE/CAs and IRAs, we get a *faster start on source removal* and that means *earlier risk reduction*. Within IRAs, we also have the ability to divide the media into soil contamination and groundwater

Using EE/CAs to select IRAs, we get a faster start on source removal and risk reduction.

contamination and pursue them separately to closure if two actions are more cost effective than one.

We have tested some Presumptive Remedies as the subject of Treatability Studies. The Data Quality Objectives (DQOs) for these Treatability Studies answer the questions: "Does the technique work here? How well? Does it scale up well? What are the drawbacks and limitations?" Occasionally, Treatability Studies are so successful that they conclude by cleaning up a site, at which time we make a finding of NFI and close the site.

Documents Under Standard CERCLA Process Under Accelerated CERCLA Process

Figure 3-9. Relative Savings in Reporting Requirements Under the Accelerated CERCLA Process

Here is an example of cost and time savings: We found that the 17-volume OU1 RI Report was difficult to read and even more difficult to comprehend. At OU2, we are not preparing traditional RI/FS reports. The RPMs have agreed that we can instead summarize the smaller documents prepared during the RI field work and IRAs. As we finished field investigations at each OU2 site, we prepared a Site Summary Report and sent it to the RPMs for their review and approval. We prepared an EE/CA as soon as we knew an IRA would be required at a site. Each EE/CA was sent to the RPMs for review and made available for a public review period. The summary of the Site Summary Reports and EE/CAs is called the

Remedial Investigation and Interim Removal Action Summary (RI/IRAS). The RI/IRAS is one volume; it sends the reader to the more manageable Site

Experimentation is often a cooperative effort.

Summary Reports and EE/CAs if more information is required. Due to the reduced effort required to prepare the smaller reports and the reduced time required to review and revise the reports, we estimate that we have **saved about \$2 million** in OU2 compared to the costs of traditional RI and FS reports. Additional savings will be realized as RI/IRAS reports are prepared for the remaining OUs.

WILLINGNESS TO TEST EXPERIMENTAL TECHNIQUES

Edwards AFB is a test facility for the Air Force and its NASA and AFRL tenants. EMR takes Edwards AFB's mission as a test facility seriously as well; testing experimental and innovative investigation and cleanup methods provides Edwards AFB and the Department of Defense (DoD) with valuable cleanup information on the technologies tested. Several of the innovative investigative and remedial techniques tested at Edwards AFB are:

- In-well Vapor Stripping;
- · Passive Soil Gas Surveys;
- · Active Soil Gas Surveys;
- Soil Stabilization;



Oxygen-Releasing Compounds

Figure 3-10. The Air Force Flight Test Center, A Willingness to Test Experimental Techniques

- Micropurge Pumps;
- CPT/ROST;
- CAVOX;
- Cometabolic Degradation;
- 2-D and 3-D Seismic Studies;
- Dual Extraction:
- · Bioslurping;
- · Bioventing; and
- Oxygen-releasing compounds.

Most of these innovative techniques are described in Chapters 4, 5, and 6.

Experimentation is often a cooperative effort among Edwards AFB, universities, agencies, and commercial companies. Edwards AFB personnel often co-author papers and present findings at seminars around the country. Sometimes the experimental programs are so successful that the test site is significantly cleaned up as a result.

EMR and the Air Force, through our presentations of lessons learned, receives a high return from EMR hosting technology demonstrations and conducting Treatability Studies with new technologies.

SHARING INFORMATION ON FORMERLY-USED DEFENSE SITES

The US Army Corps of Engineers has been tasked to manage Formerly-Used Defense Sites (FUDS) and



Figure 3-11. David Price at Edwards FUDS

their efforts are overseen by an office in DTSC. Though FUDS are not managed by EMR, our public and the RAB worry about them. We listened to the community's concerns and asked a representative of the state FUDS program to brief our RAB on their activities and answer questions. In turn, our RAB members were able to reassure their neighbors and coworkers that the state was aware of their concerns.

There was another benefit from our having the briefing. Edwards AFB "old timers" pointed out other former defense sites to the state representative, and EMR's archival research was shared with the state and the Corps of Engineers, pointing out FUDS to them in the immediate area of the Base.

NATURAL ATTENUATION OCCURRING ALL THE TIME

During 1997-1998, while examining the groundwater modeling of chlorinated solvents and jet fuel in OUs 4 and 9, we recognized that natural attenuation (NA) was already at work reducing contaminant concentrations in the groundwater. That discovery quickly made our efforts more effective in three important ways:

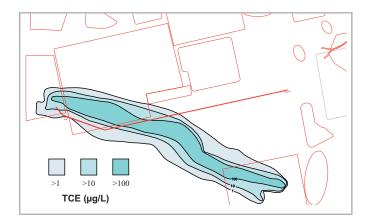


Figure 3-12. TCE Groundwater Contaminated Plume Measured in µg/L

- It underscored the real value of removing the source of the contamination, that is, removing the "hot spot." The leading edges of plumes were already undergoing NA—it is sometimes only necessary to remove the highest concentration of the source to give the natural conditions a chance to take over the cleanup.
- When we added factors for NA to the groundwater models, the models fit better, increasing EMR's credibility, and underscoring that NA was already underway.
- We began to collect additional groundwater chemistry data during the investigation phases to prove the effectiveness of NA.

We are following the Air Force Center for Environmental Excellence (AFCEE) "Technical

Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater." At Site 15 in OU2, the site of a pipeline leak, we are studying the applicability of the AFCEE protocol by sampling groundwater twice a year. We chose the site carefully because NA may be all the cleanup the site needs. The RAB agrees that the site is too small to require another response. The result: when the NA study concludes and the site is closed, the study will have cost less than one-quarter of the cost of an active response to a pipeline leak—probably only \$100K versus \$400K.

DEVELOPMENT OF BACKGROUND METALS CONCENTRATIONS

Using existing data to yield more information is always a better return on our investment than generating new data. We're always searching for ways

We used **existing** data to yield **more** information.

to combine existing data to yield new information.

Knowing the naturally occurring, or background, concentrations of metals in soil

and groundwater is essential to knowing whether an IRP site should be cleaned up. Soil and groundwater at Edwards AFB are rich in metals and water-soluble metals salts. Many of the background concentrations are above regulatory limits. In OU4, naturally occurring concentrations of beryllium and arsenic are up to 100 times higher than regulatory limits. We knew that it would be foolish for us to clean up the soil and groundwater to levels below those that are naturally occurring. It was, therefore, necessary for us to determine a cost-effective way to gather background metals data. We did not want to collect and analyze hundreds of new samples to develop the background levels. Instead, we were able to work with the RPMs to use the metals results from soil and groundwater samples that did not include metals among their contaminants of concern. This allowed us to calculate background metals concentrations

Background studies for 469 Sites/AOCs at only \$5,000 per site **would have cost us \$2,345,000**. We're also generating big cost savings by having officially

without having to obtain a single new sample.

documented the high concentrations of some metals in our native soils. We don't have to seek agreement about our high background levels at site after site, and we don't have to clean up to a lower concentration than the existing background levels. Saving just 40 hours a year in negotiating high background levels for our 469 Sites means we save \$938,000.

Right after the OU-specific Background Metals documents were published, several sites where metals were present immediately qualified for NFI status.

In 1995, we produced our Programmatic Background Metals Procedure Document. With background concentrations now known over a wide expanse of the Base, several sites immediately qualified for NFI status. At other sites under investigation or cleanup, we take no further action for metals unless metals concentrations are above regulatory limits, above the background levels, and levels pose a significant risk that requires reduction.

We extracted even more value from the same data; other EM Divisions have used our Background Metals Documents. Quality Division received a Regional Water Quality Control Board (RWQCB) Order to monitor wells near the evaporation ponds at South

Base and was concerned with the "high" metals concentrations. The South Base Background Metals in Groundwater document showed the Quality Division that the metals concentrations, while in some cases above regulatory limits, were below background levels.

The Background Metals documents have been applied to other Divisions and other projects.

TIME-CRITICAL REMOVAL ACTIONS

In 1998, AFRL alerted EMR that there was a rocket motor for a Short-Range Attack Missile (SRAM) that had been in storage too long. AFRL wanted advice on how to dispose of it safely. SRAM motors are very



Figure 3-13. SRAM Missile

unstable, and static- and shock-sensitive. In fact, the motor parts can only be exposed to air for a total of thirty minutes during their life, after which they begin to degrade and become more dangerous.

EMR wanted to provide effective help and do so quickly. The situation was dangerous. Responding to the imminent threat to human health and the environment, EMR used its authority under CERCLA to conduct a Time-Critical Removal Action:

- Using AFRL project funds, EMR prepared the EE/CA showing that the safest approach to the threat would be to evacuate the area, use remotecontrolled equipment to carefully move the motor from storage to a safe distance away from the building, and then blow it up.
- The RPMs, nearby communities, and all other stakeholders were provided an opportunity to comment on the EE/CA. Helpful suggestions about the operation were made part of the plan.
- The operation was planned and practiced.
- The motor was moved to Site 1-36D and safely destroyed.

What could have been a disaster and a public relations nightmare is now remembered as just another workday in 1998. The Time-Critical Removal Action kept everyone safe and brought other benefits too:

- The public and the agencies are familiar with the steps in CERCLA and how it works, so they were ready to work with it;
- Permitting did not slow down the rapid response because no permit was required;

- The EE/CA was a simple, short document that everyone could comment on; and
- The Action Memorandum was a single, trackable document that showed responses to everyone's comments, and yet did not dilute the RPMs' or the lead agency's initiative with stacks of reports and comments.

A point that helped our stakeholders understand our using CERCLA, not RCRA, for this action: RCRA is a prescriptive law and regulation meant to cover the repeated process of handling and manifesting the same waste over and over. RCRA emergency responses do not allow for detailed planning. CERCLA is a process we, our RPMs, and our stakeholders are familiar with for breaking responses into detailed steps. RCRA is not ignored. It is an ARAR under CERCLA.

USING CERCLA TO CLEAN UP RCRA OB/OD SITES

Edwards AFB has two former open burn (OB) units and one open detonation (OD) unit that were used for the destruction of waste propellant from the research laboratories at AFRL and explosive and pyrotechnic items from Base operations. The three units were being cleaned up and closed by EMC in conjunction with the RCRA permitting of a new base-wide OB/OD site. EMC was conducting the permitting process, so EMC was also responsible for the cleanup. Because the effort to clean these sites was delaying permitting of the new OB/OD site, EMR proposed



Figure 3-14. Edwards Air Force Base Open Burn Site

that the permitting and cleanup tasks be separated. EMC would continue the permitting process for the new site. EMR would conduct the cleanup under CERCLA using RCRA as an ARAR. This would allow the permitting process to continue without delay and also provide a coordinated effort to close the old OB/OD sites. EMR met with RCRA and CERCLA DTSC representatives and put forth the proposal. The regulatory agencies agreed with the rationale for separating the two actions.

Anyone who has conducted RCRA cleanups will recognize the benefits of this approach:

- The sites can be closed based on the risk they pose versus specific contaminant concentrations; and
- The closures can be efficiently and effectively managed within the overall investigation, cleanup strategy, and timeline for Edwards AFB.

"CLEANUP REQUIREMENT INFORMATION SYSTEM" SOFTWARE

We developed software that allows us to arrive at accurate ARARs more quickly and easily. In the Time-Critical
Removal Action and the
OB/OD closures, we were
required to consider
RCRA among the ARARs
for those actions. We are
asked to generate a list of
ARARs each time we plan
a cleanup or a risk
reduction action. For
hundreds of sites, that can

become time consuming. Moreover, when agency personnel are short of time or experience, the discussions on the ARARs that should be in force are sometimes not simple discussions.

In 1996, EMR decided to develop a decisionsupport tool that would:

- Help Edwards AFB and the other RPMs arrive at accurate ARARs more quickly and easily;
- Produce an accurate list of ARARs for each site that is consistent over similar sites;
- Produce ARARs that are consistent over time, regardless of change in personnel at the regulatory agencies or at the Base;
- Be quick and easy to use;

- Be easily updatable;
- Reflect the list of Lessons Learned at Edwards
 AFB from the experience of PMs past and present;
- Present the Lessons Learned so that the PMs can pre-engineer their systems to avoid certain designs and expensive steps that did not work out well in the past; and
- Contain ample "Help" files on everything from regulatory definitions and actual up-to-date text of regulations to instructions on how to use the system.



Figure 3-15. Cleanup Requirement Information System Database

The system EMR developed fulfills all these requirements. The Cleanup Requirement Information System (CRIS) database and software generates and prints out the list of ARARs. The software even prints out the list of site characteristics the user did not know. The user can consult the list to gather additional information about the site. Included on the compact disk with the software are:

- A complete set of California cleanup regulations;
- An electronic User's Manual;
- An electronic "tour" of the software for the firsttime user; and
- An instructional video that walks the viewer through the development and applications of the software.



Figure 3-16. Edwards Air Force Base Soil Farm

RECYCLING CLEAN AND TREATED SOIL AS LANDFILL COVER AND BACKFILL

The IRP generates tons of drill cuttings and clean overburden from excavations. We also generate fuel-contaminated soils that are expensive to transport and dispose of, but which are not difficult to clean up if space is available. We needed to determine what to do with our excess soil.

The Base Landfill needs soil for "daily cover" to cover trash piles at the facility. Clean soil is not always available on base because construction has slowed down. We want to minimize use of our existing borrow pits.

EMR's Base-wide Plan for the Management of Investigative-Derived Waste (IDW) and EMR's Soil Farm provide soil for "daily cover" without the need to dig another borrow pit. To reuse drill cuttings and overburden as landfill daily cover, we:

- Stage the soil;
- · Sample it; and
- If it is clean, transport it to the landfill for use as daily cover.

If the soil is not clean enough to use, we clean it ourselves. EMR built its soil farm in 1995. It uses ex-

We were ahead of our time. Now commercial vendors are offering inexpensive soil treatment. situ bioventing to treat fuelcontaminated soil. The treated soil can be used as fill dirt in industrial or outlying areas of the Base.

The Soil Farm treated an average of 1,000 tons of dirt a year. With its ability to return soil to us, the farm **paid for itself**. We no longer had to buy fill dirt from off base or pay to have soil treated or disposed of off base. The annual operations and maintenance (O&M) cost for the Soil Farm was roughly \$160,000, which was about what we would have had to pay to transport, treat, and dispose of the contaminated soil. In the past, our Soil Farm:

- Cleaned the soil and reduced the risk that it would be a continuing source of contamination;
- Eliminated the liability from off-site transportation and disposal; and
- Provided a ready source of clean fill dirt.

The Soil Farm was one of the first such facilities in the state. At capacity, it held 5,000 yards of soil stacked in 10-foot high piles.

In recent months, nearby commercial vendors have begun offering soil recycling at prices that compete with our Soil Farm, so we will be phasing it out. But for three years, it offered us a risk-free treatment option at very little cost.

FINDING UNEXPLODED ORDNANCE AND ADDRESSING THE RISKS

EMR has begun planning how to locate and deal with unexploded ordnance (UXO). First, to address safety, we survey our fenceline to ensure that it is intact.

Next, we did something innovative that **saved about \$100,000**. During our archival research for

Chemical Warfare
Materiel (CWM)
activities at Edwards
AFB, we discovered that
the CWM records also
showed the locations of
old targets on our ranges.
We assembled the target
location data into maps
and placed the maps into
our Geographic
Information System
(GIS). The maps allow

We assembled the target locations into GIS maps allowing us to identify, categorize, and manage the target sites.

us to identify, categorize, and manage the target sites.

In the future, when Edwards AFB conducts a range or UXO inventory, we will be at least a year ahead of other facilities performing similar inventories. The

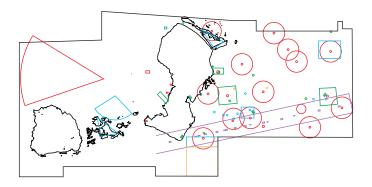


Figure 3-17. Edwards Air Force Base Conventional Ordnance Ranges and Targets

target information came to us "free"; we were already searching the archives for CWM data.

Because we already have a good start on mapping locations where UXO might be found, we predict that we will be better positioned to scope and manage the UXO and range clearance program.

ADDRESSING UXO RISK AT IRP SITES

We would like to find a way to clear a large area for the presence of UXO without requiring a UXO contractor to be on hand to clear every subsurface effort, three feet at a time. For safety reasons, the method should be non-intrusive.

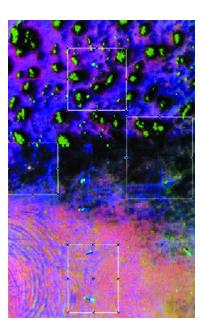


Figure 3-18. Multispectral Imagery of Surface Bomb Locations

While conducting the helicopter-based geophysical surveys for potential buried CWM, Department of Energy scientists contracted by EMR found that the instruments were also effective at pinpointing surface metal objects. Further tests showed that the instruments

could detect bombs and other metallic objects as small as 30 pounds.

EMR uses airborne and ground-based geophysical sensors as non-intrusive methods for screening the range and surrounding areas for UXO before beginning Helicopter-based sensors can detect surface UXO weighing as little as 30 pounds.

field investigations. We are pleased that we can minimize the use of ground-based geophysical surveys in areas of critical habitat.

SITE RANKING USING RELATIVE RISK

With over 460 Sites/AOCs and ten OUs, it could be difficult to decide where to begin our investigations. Since 1994, we have assigned "high," "medium," or "low" levels of relative risk to sites. This ranking has helped us prioritize our efforts and meet the expectations of our RAB members.

Ranking brings three other important payoffs:

- Our funds go further to reduce risk because we work on the worst sites first, (except in a few cases when urged by our RAB or by our common sense to work on lower relative risk sites sooner);
- Ranking brings along with it a bias for action because we know where to act and how to act; and
- Our RAB fully embraces risk as the tool to guide our actions.

Relative risk rankings are calculated by the Air Force Restoration Information Management System (AFRIMS) Relative Risk Module. Relative risk is compared across sites by considering:

We have assigned "high," "medium," or "low" relative risk to sites.

- the contaminant hazard;
- the migration pathway; and
- the receptor.

Addressing sites in the order "worst first" is not an absolute; there are several cases where we would address lower risk sooner than indicated by our risk-based prioritization:

 When a customer on a medium-risk site is having to contend with excessive personal protective equipment for his employees or excessive land use controls;

High risk sites command 80% of our efforts.

- When addressing a site is important to a RAB member;
- When a site is in the way of the Base executing its mission; and
- When there is a small amount of contamination that can be excavated and taken to the Soil Farm for treatment, allowing the site to be closed.

Even with these exceptions, 80% of our efforts are spent on high-risk sites.

There is a fault in the relative risk evaluation procedure that concerns us. The procedure is biased toward contamination in surface soil, surface water, and groundwater, and does not recognize contamination in soil below six inches. Because our airmen and contractors on the Base dig in soil deeper than six inches, we must also consider deeper soil contamination when prioritizing sites for cleanup.

EE/CAS ARE PRIMARY DOCUMENTS; SCHEDULES ARE ENFORCEABLE

The RPMs are well educated about Air Force funding cycles and the amount of IRP money available. They have also concluded that the annual IRP budget can buy more EE/CAs and IRAs that reduce more risk than buying a single, huge, conventional CERCLA document (for example, an RI or FS Report) at the conclusion of which, risk is not reduced, just well-catalogued!

We can purchase four or five EE/CAs and IRAs for the cost of a single RI or FS Report. Our RPMs have

Reducing risk is the best way to spend our money.

decided not to spend budget on larger and larger RIs, but on more EE/CAs and IRAs, because we have shown how far those actions can go in reducing risk, and the RPMs recognize that reducing risk is the best way to spend our money.

We prepare the EE/CA as soon as we have contaminant data that indicate a cleanup is warranted, and we perform the IRA the following year. The RPMs join us in prioritizing which EE/CAs we will do, rather than criticizing us for not doing more. We have agreed that EE/CAs are primary documents, and the related Schedules-To-Complete are enforceable on two-year calendars.

A SINGLE BASE-WIDE ROD, HRA, AND ERA

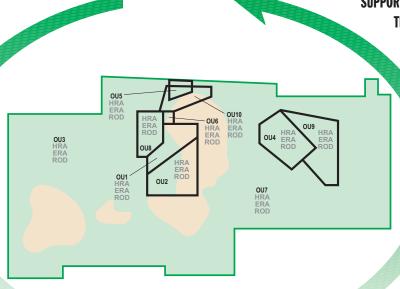
It is estimated that Edwards AFB will **save \$55 million** by using accelerated CERCLA methodology and by preparing a single, base-wide Health Risk Assessment (HRA).

ERA, and Record of Decision (ROD). What is a ROD? A ROD is a document of conclusion—it should bring the risk reduction process to a close rather than just begin the process. A final ROD should be used to describe the decisions

HRAs should only be conducted on the contamination left in place or where remediation has not been initiated.

made about the residual contaminant levels.

What is the purpose of HRAs? HRAs assess the risk of contaminants to human health. Contaminants above MCLs or Preliminary Remediation Goals (PRGs) are recognized to pose a potential risk to human health. We know that it will be necessary to reduce the risk posed by these contaminants. Therefore, HRAs should only be conducted on the contaminants left in place, or where remediation has not yet been initiated. Edwards AFB's final HRA will do just that. When the draft ROD is published on 6 July 2004, the final HRA and the ROD will describe the remedial actions that have been completed, are ongoing, or are planned. They will also describe sites where there is residual contamination. At these sites, institutional controls that will prevent access to the contamination will be explained.



Single ROD, ERA, and HRA

Figure 3-19. Single, Base-wide ROD, HRA, and ERA Will Save Millions of Dollars.

Edwards AFB will save \$55 million by not preparing additional HRAs, ERAs, and RODs. We realized years ago that SACM gave us the authority to decide to prepare one base-wide ROD instead of ten RODs for our ten OUs. Edward AFB will prepare a single base-wide ROD, a single final HRA, and a single final ERA.

Preparing only one base-wide ROD has allowed us to implement more IRAs.

We will discuss cleanup goals with the RPMs after we know how well the cleanup technologies will work. It is estimated that Edwards AFB will **save \$55 million** by not preparing the nine additional HRAs, ERAs, and RODs.

SUPPORTING THE ROLE OF THE NATURAL RESOURCE TRUSTEES

Paying the bill to correct the natural resource damages identified by the Natural Resource Trustees could potentially be more expensive than the IRP investigations and cleanups themselves. We educated ourselves about the requirements, and we are planning programmatically. Natural resource planning and documentation for the Trustees should not be left until the end of the program.

The Trustees care about all the Base's resources: animal and plant resources, and surface water, water, groundwater, and drinking water. To respond to the Trustees' eventual request for natural resource injury documentation, EMR continually documents the nature of releases, the cleanup steps taken, a description of construction and roads, a description of what contamination was left behind, and *most importantly*, whether there were any effects on resources and what steps have been taken to mitigate the effects.

Our 24 programmatic initiatives in this chapter have **saved or avoided costs of \$71 million**. Chapters 4 through 7 describe the same kinds of initiatives and an **additional \$12.3 million** in savings in investigation techniques, information management, risk reduction innovations, and community involvement initiatives.

CHAPTER 4

INNOVATIVE INVESTIGATION TECHNIQUES

EMR must determine the nature and extent of contamination at Edwards AFB. The Base has the following characteristics:

- Military operations since 1933;
- Over 470 square miles in area;
- Five active areas of operation, each area as large as some entire military bases;
- Multiple tenants including NASA and AFRL;
- · Complex geology and hydrogeology; and
- Contamination that includes jet fuels, chlorinated solvents, rocket propellants, UXO, and chemical warfare materiel.

We cannot perform subsurface investigations by drilling at every site; there will never be enough funds for that. We have to use other resources to narrow the area and decrease the number of sites where we will drill. How do we do that? We have found that with a combination of Preliminary Assessments (archival research and interviews with retired employees) and Site Inspection (passive and active soil gas surveys), we can assess a great number of sites quickly. Using this combination of techniques costs an order of magnitude less than a conventional drilling and sampling program. For the cost of a single conventional 5-day drilling and sampling event at a single site, we can assess seven to eight sites using archival research, interviews, and soil gas surveys. When we've completed our Preliminary Assessments and Site Inspections, we know where to drill.

We've proven over and over again in our field investigations that beginning with the simpler, less expensive techniques of archival research, interviews with retired employees, and soil gas surveys gives us a 7-to-1 or better return on the resources spent on investigations. We've organized our cost-saving steps into a system, a decision hierarchy, that we use in site investigations. The hierarchy begins with simpler and less expensive techniques and leads through to the most expensive techniques. Our goal is to focus our resources on the early less-expensive stages to ensure

we are employing more expensive, time-consuming techniques at the sites that warrant the additional effort. The hierarchy also considers each technique's effects on our environment and our ecosystems; more intrusive methods are at the top of the hierarchy. In a real demonstration of the value of our investigation hierarchy, we have learned enough about sites using only the less-expensive techniques to suggest sites for "No Further Investigation" (NFI) required.

Often only minimal confirmatory soil and groundwater sampling are required to obtain NFIs from the RPMs. Receiving NFI decisions very early in the history of a site generates significant cost savings.

This chapter is about our investigation hierarchy and the breakthroughs we've experienced using it. Here are the techniques:

- Archival Research;
- Retired Employee Interviews;
- · Geophysics;
- · Remote Sensing;
- · Soil Gas Surveys;
- Cone Penetrometer Testing (CPT);
- Cone Penetrometer Testing (CPT)/Rapid Optical Screening Tool (CPT/ROST);
- Sampling, Technology Assessment, and Remediation (STAR) rig;
- · Boreholes and Monitoring Wells;
- Downhole Video Assessments; and
- Tracer Studies.

Not every technique is applicable at every site, but when these techniques are used, they are used in this order.

Before the first field work is performed at a site, it is advisable to determine how you want to use the data. This includes the establishment of smart, well-reasoned Data Quality Objectives (DQOs).

Over 460 sites have been identified at Edwards AFB. Each site requires investigation and may require risk reduction.

WELL-REASONED DATA QUALITY OBJECTIVES

Every Project Manager is in the business of obtaining and interpreting data. DQOs identify which data are needed, why those data are needed, and how much data should be acquired. DQOs also describe how the data will be transformed into useful information.

The first step toward a successful and cost-effective investigation is to establish DQOs that provide the required data with the fewest samples.

Without a clearly

defined end use for the data, it is common for more data to be obtained than are necessary.

At Edwards AFB, we:

 Develop DQOs early in the field investigation planning stage of a project;

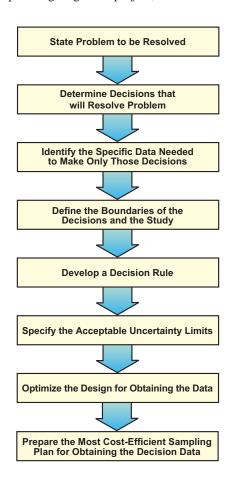


Figure 4-1. Creating Smart DQOs

- Customize the DQOs for each effort and do not assume that DQOs developed for one site can simply be used at multiple sites;
- Ask the following questions when creating the DQOs:
 - What samples do I need?
 - Why do I need the samples?
 - How will I collect them?
 - How will I know when I have enough samples?
 - How will I maintain sample integrity?
- Question the need for expensive quality assurance/quality control procedures during site screening investigations or interim monitoring rounds;
- Use screening techniques whenever possible until there is a compelling reason to use more rigorous techniques; and
- Understand that a wise use of our resources is the creation of well-thoughtout DQOs.

Effective use of the DQO process has resulted in

Knowing how to effectively develop and use DQO has resulted in substantial cost savings at Edwards AFB.

substantial cost savings for Edwards AFB. With 160 sites currently under investigation at an approximate sampling and analytical cost of \$100,000 per site, use of smart DQOs has focused our field investigations and saved us at least 10 percent of the costs per site. This has resulted in a **savings of approximately \$1.6 million** dollars to date for this program.

HIERARCHY OF INVESTIGATION METHODS

We recognize that techniques available to investigate sites can be ranked according to their degree of environmental intrusiveness, their impact on personnel safety, and the time and resources required to complete them.

In evaluating the range of investigation techniques, the results we can obtain from relatively simple, nonintrusive methods allow us to:

 Justify the use of more intrusive, more expensive techniques of investigation; or

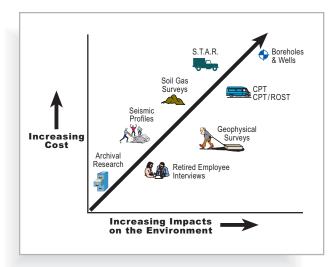


Figure 4-2. Edwards Air Force Base Hierarchy of Investigation Methods

• Rule out the need for any additional investigation at a site.

With either result, applying this type of progressive thinking saves both time and money during field investigations.

For example, of the over 460 sites identified at Edwards AFB, 265 sites have been approved for NFI by the RPMs. Closure was often obtained by using the simpler investigative methods at the bottom of our hierarchy, followed by a minimal amount of intrusive sampling. At sites where a more extensive investigation was warranted, the screening results were used to focus the more intrusive sampling efforts on specific small areas and thereby save considerable drilling and sampling costs.

ARCHIVAL RESEARCH

Every significant environmental investigation at Edwards AFB began with archival research. In many instances, the first step was finding and reviewing old aerial photographs. Edwards AFB maintains an

Photographic archives reveal locations of many old buildings and old sources of contamination.

extensive collection of historical aerial photos dating back to the 1940s. We have also traveled to several History Offices and National Archives to research activities at Edwards AFB between the 1930s and the 1980s. These

Archival Research projects have yielded a wealth of information about past sources of contamination.

Many of the facilities in the photos no longer exist, but their locations can be accurately mapped. Our search of photographic archives has revealed the locations of old gas stations, training areas, operations



Figure 4-3. Chemical Weapons Training at Edwards Air Force Base in the 1940s

and maintenance buildings, storage buildings, and disposal areas.

CWM testing, training, and disposal were conducted at Muroc Army Airfield, now Edwards AFB, in the 1940s. Historical archives have been especially useful in identifying the locations of the CWM staging and

disposal areas, as well as bomb targets and gunnery ranges. Our research efforts identified 25 sites that may have been associated with the testing, training, or storage of CWM.

INTERVIEWS WITH RETIRED EMPLOYEES

Most of the information about the historical handling and disposal practices for hazardous materials and hazardous waste is not written down. We decided to locate and interview retired employees; the information they've given us has

Former employees have been invaluable in showing us potentiallycontaminated areas.

proved invaluable in finding potentially-contaminated sites and identifying the contaminants.

When considering the variety of activities previously conducted at Edwards AFB and the number of years the Base has been in existence, it would have been nearly impossible to conduct an effective environmental restoration program without the information provided by the "old timers."

In summary, our employee interview program:

- Records information on activities from the 1940s to 1980s that would have been lost if not documented;
- Tells us what standard handling and disposal practices were for hazardous waste and materials in the past;

A question concerning previous activities at a site was answered when Wade Martin, a former rocket engine technician, visited the Base and described the site's historical background. Martin worked at Edwards AFB from 1951 to 1981.

- Has very low costs associated with conducting the interviews compared to the value of the information gained; and
- Resulted in the creation of three new Areas of Concern (AOCs 458, 459, and 460) for additional investigation that might not have been found otherwise.

We use some creative methods to find and contact previous employees. We post notices in newspapers and on our web site, and we display flyers and posters on base and in our communities. We also seek out the newspapers and newsletters of retiree organizations and post notices there.

The employee interviews are also part of EMR's effort to inform and involve the community in the



Figure 4-4. Interviewing retired employees has provided invaluable historical information.

actions to clean up the Base. The IRP staff recognizes the limitations in the existing written records and enthusiastically solicits feedback from both the community and former employees.

USE OF GEOPHYSICS

Understanding the nature of the subsurface without drilling holes in the ground requires using very sophisticated techniques. We use non-intrusive geophysical techniques, including:

- Electromagnetics;
- Ground Penetrating Radar (GPR);

- · Magnetics; and
- Two-Dimensional and Three-Dimensional High Resolution Seismic Reflection.

It is our standard practice to perform geophysical surveys before starting expensive drilling. More details are shown below.

SEISMIC PROFILING OF THE SUBSURFACE

Used effectively in the oil exploration industry for many years, Edwards AFB was one of the first bases in the nation to apply high-resolution Seismic Profiling to an environmental cleanup program. The method has provided significant data that can potentially save thousands of dollars that would have been spent in less focused drilling programs. Seismic profiling makes a critical difference in being able to place wells in areas on the Base with fractured bedrock where the wells will yield the most groundwater and provide a better opportunity for cleanup.

Seismic profiling was conducted at Edwards AFB over an area of approximately 16 acres. Sound waves were generated by thumping a steel plate on the ground surface with a 16-pound hammer. Listening devices called "geophones" measured the time required for the sound waves to travel from the surface through varying layers below the ground and return to the surface detectors. A computer analyzed the sound versus time data and generated the subsurface images.

The imaging technology of three-dimensional (3-D) high-resolution seismic profiling provides geologists with a clearer picture of the lithology and fracture zones beneath sites at Edwards AFB. Seismic profiling generates a two-dimensional (2-D) or 3-D image of the subsurface that can even assist in identifying the most likely location of contamination.

Two-dimensional (2-D) seismic profiling is less expensive than 3-D profiling. At Edwards AFB, we use 2-D profiling first, then use 3-D profiling judiciously at a few locations to keep the cost down.

We use seismic profiling to:

- Characterize the subsurface;
- Identify areas of high and low permeability (fractured bedrock);

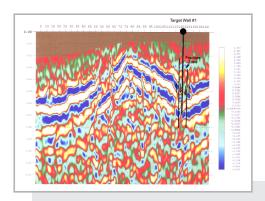
- · Locate potential water-bearing zones; and
- Optimize the placement of groundwater monitoring and remediation wells.

The first well drilled at 0U4 based on seismic imaging yielded groundwater flow rates four times greater than existing wells installed in the area.

The seismic
"pictures" are used to
place groundwater
extraction and
monitoring wells in areas
where the greatest
groundwater yields can
be expected. In some
areas of Edwards AFB,
groundwater is
approximately 150 feet
below the surface. At a

cost of up to \$30,000 per well, placing a large number of groundwater wells using the usual methods is too expensive.

The first groundwater well drilled using seismic images yielded water at five gallons per minute, nearly **four times greater** than the existing wells at the site. Based on this success, we'll continue to use seismic profiling to place wells in fractured bedrock.



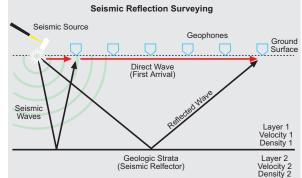


Figure 4-5. Field Image and Seismic Profiling Method (Vertical Line on the Field Shows the Probable Fracture Zone)

USING REMOTE SENSING

Edwards AFB has been very successful in taking technologies developed outside the environmental arena and adapting them for use within the IRP. Among the most recent successes has been the use of remote sensors to locate buried objects and CWM.

One of our challenges has been to identify the location of previously buried CWM and ordnance over the large areas that comprise Edwards AFB. The most effective means to accomplish this task is through aerial surveys using remote sensors.

Helicopters carrying specialized remote sensing equipment developed by Oak Ridge National Laboratory were used for aerial surveys. Aerial surveys using remote sensors were used to identify the potential locations of buried CWM and ordnance over large areas.

In 1997, two helicopters surveyed a World War IIera Chemical Warfare Materiel Storage Yard and parts of the Precision Impact Range Area at Edwards AFB. The sensing equipment on the helicopters included:

- · Video Cameras:
- · Electromagnetic sensors;
- · Magnetometers; and
- Twelve-channel multi-spectral imagers.



Figure 4-6. Helicopter Carrying a Magnetometer

The sensitivity of the sensors was tested prior to performing the aerial survey. Various-sized metal objects were purposely hidden in an area on the range and were surveyed by the helicopter remote sensors.

The multi-spectral imager was the most successful, finding 100% of the planted objects. Subsequent results of the helicopter aerial surveys indicated that they were able to accurately detect metal objects weighing as little as 30 pounds on the ground surface.

The multi-spectral imagers contained thermal infrared sensors that were particularly effective in finding objects on the surface, in bushes, and buried in shallow soil. The images rely on temperature differences between the objects and background.

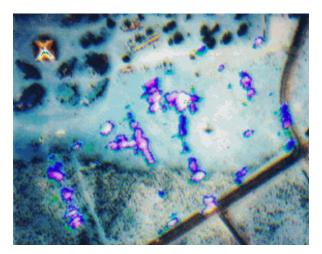


Figure 4-7. Aerial Remote Sensing Output (Locations of Metal Objects in Pink Color)

SOIL GAS ANALYSES

When more definitive information is required to screen and identify possible contamination at a site, we often use soil gas surveys. Soil gas surveys involve collecting and analyzing samples of vapor from the subsurface, either passively or actively.

Passive soil gas surveys are:

- Non-intrusive and therefore can be effectively used in areas with many buried utilities;
- Simple to use and involve placing absorbent materials under metal containers and sealing the containers to the ground surface;
- Relatively fast because the absorbent materials are retrieved after only a few days and analyzed for volatile contaminants;
- Effective in evaluating a large area because many containers can be placed in a grid over a sizable area to "map" the contaminant distribution; and

 Limited because the analytical data are qualitative and are of a "relative" nature.

At Edwards AFB, passive soil gas surveys have been successful at solvent- and fuel-contaminated sites and in identifying the potential chemical degradation products at CWM disposal sites. Active soil gas surveys are different from passive surveys and are described as follows:

- The process is a more intrusive technique that involves driving a thin probe to a specified depth
 - and extracting soil gas with a vacuum pump;
- The extracted vapors can be analyzed immediately on site with a mobile laboratory to provide rapid characterization of the site and realtime data to direct additional sampling;

Over 700 active soil gas surveys were performed during the investigation of OU2. The real-time data allowed mapping of the lateral extent of contaminated areas without the expense of an extensive drilling program or the lag time involved with waiting for sample results.

- As many as four probes can be installed and sampled in one hour at a cost of approximately \$100 per sample point;
- The process is much faster and cheaper than drilling soil boreholes; and
- The results from active soil gas analyses are considered qualitative.

Both passive and active soil gas surveys have been used effectively at Edwards AFB as precursors to

SOIL

LAYER

more intrusive soil boring and sampling. The data from these surveys have been used to

determine the proper placement of boreholes and groundwater monitoring wells.

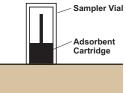


Figure 4-8. Passive Soil Gas Collection Technique

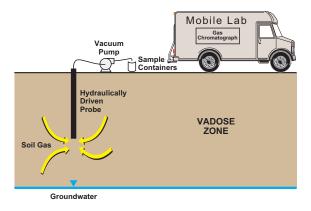


Figure 4-9. Active Soil Gas Surveys

CONE PENETROMETER TESTING WITH RAPID OPTICAL SCREENING TOOL

The use of CPT provides an accurate, fast, and relatively cheap method of evaluating subsurface lithology. ROST can be added to delineate contaminant plumes. CPT/ROST is an investigative tool that can provide analytical data for both soil and groundwater. It also provides an accurate means of siting additional groundwater monitoring wells if necessary.

CPT and CPT/ROST are described as follows:

- CPT is quick and does not generate drill cuttings.
- CPT involves driving a probe into the ground without drilling.
- The CPT probe tip can be modified to collect soil and groundwater samples, or can include direct resistance or ROST sensors.
- Resistance sensors can continuously record information on soil types as the probe is driven into the subsurface.



Figure 4-10. Cone Penetrometer Equipment

The ROST sensor includes a laser that causes hydrocarbons in the soil to fluoresce. A fiber-optic line carries the fluorescence information to a computer that creates a contaminant profile.

Seventy-five traditional soil borings to 50 feet cost \$5,000 each. We've completed 75 CPT/ROST "borings" to 50 feet for \$1,000 each, for a savings of \$4,000 per location, or \$300,000 in savings overall.

The CPT/ROST sensors were tested

at Edwards AFB by drilling and logging a small number of soil boreholes directly adjacent to CPT/ROST points. Soil samples were collected from the boreholes and analyzed by a laboratory. Results of the CPT lithologic data, the ROST contaminant data, the soil borehole logs, and the lab analyses correlated strongly with each other.

Because of the strong correlation, regulatory agencies approved the use of CPT/ROST for much of the site characterization work at OU2 and other Operable Units at Edwards AFB. The ROST equipment also provides a method of screening groundwater for the presence of hydrocarbons without the need to collect a sample.

CPT and CPT/ROST offer considerable cost savings by providing the same subsurface information for \$1,000 per sample point compared to \$5,000 or more per point using conventional soil boring methods.

SAMPLING, TECHNOLOGY ASSESSMENT, AND REMEDIATION (STAR) RIG

Taking the initiative to reduce site investigation costs, EMR obtained a three-ton truck from the Base Transportation Squadron and outfitted it with a completely self-contained drilling and sampling system. Known as the STAR rig, the unit has dramatically reduced sampling costs and response times in support of environmental site investigations at Edwards AFB.

Edwards AFB believes the STAR rig may be the first of its kind to be built and used by the U.S. Air Force. The STAR rig is used by EMR personnel to conduct initial assessments at new sites or AOCs quickly and cost-effectively. If more intensive investigations of a site are required, they are contracted out.

Although not capable of sampling at the depths achievable with larger drilling rigs, the STAR rig includes the following equipment:

- A hollow-stem auger with hydraulic direct push capability;
- A built-in equipment decontamination station;
- Potable and gray water storage tanks;
- A 2,000-pound lifting crane; and
- Support equipment such as an electric generator, air compressor, and a submersible groundwater pump.

Much of the equipment for the STAR rig was obtained as surplus from other Edwards AFB programs at a considerable cost savings.



Figure 4-11. Drilling a Borehole on Rogers Dry Lake Using the STAR Rig

the STAR rig for screening sites has also resulted in substantial cost savings for Edwards AFB. With over 160 AOCs investigated, the STAR rig

Use of

has provided higher flexibility, more rapid mobilization, and lower cost than off-base drilling contractors. We calculate that we have **avoided \$156,000 in drilling costs** since the beginning of the STAR program.

BOREHOLES AND MONITORING WELLS

The Edwards AFB IRP has determined that allowing flexibility in a design can be an important cost-saving concept, even when it involves the installation of soil borings and groundwater monitoring wells. Other than soil excavation, the drilling of boreholes is one of the most intrusive investigative methods used at IRP sites.

Due to the relatively high environmental intrusiveness associated with drilling, most Edwards AFB often specifies "oversized" groundwater monitoring well casing diameters.

of the investigative techniques discussed up to this point provide information on minimizing the number of borings required and ensuring their optimum placement. The expenses associated with the installation of exploratory borings and groundwater monitoring wells include:

- · Contracting;
- Mobilization;
- Utility clearance;
- Natural and cultural resource protection;
- · Waste handling;
- · Decontamination; and
- Demobilization.

At many installations, the diameter of the soil boring or monitoring well is designed to be as small as possible based on the assumption that a minimum size will result in the lowest overall cost. However, this practice can end up restricting the usefulness of the well for future remedial actions (i.e., causing



Figure 4-12. Monitoring Well Installation

additional drilling requirements at the site).

When appropriate, Edwards AFB personnel specify "oversized" groundwater monitoring well casing diameters in anticipation

of future potential requirements.

Oversized monitoring wells have the advantages of:

 Providing access for specialized equipment such as logging tools, cameras, or unique monitoring equipment;



Figure 4-13. Logging Soil Borehole Samples

- Being easily converted to extraction wells to accommodate downhole extraction equipment such as dedicated pumps; and
- Reducing the net site cleanup costs since each time a well is planned, potential future uses are considered.

DOWNHOLE VIDEO ASSESSMENTS

In many areas at Edwards AFB, groundwater is not encountered until bedrock is reached. Potential contamination such as trichloroethene (TCE) may be located in the bedrock fractures.

Video cameras were used in order to see bedrock fracture zones.

Monitoring this type of contamination and its dispersion requires an understanding of the nature and extent of the fractures.



Figure 4-14. Inserting a Downhole Video Camera into a Well

At OU6, Edwards AFB personnel lowered video cameras into boreholes drilled into bedrock in order to see the fracture zones. The cost of performing a video survey was approximately \$1,000 to \$2,000 per borehole. Borehole videos provided a picture of the bedrock fractures and the groundwater yield through each fracture.

The downhole video surveys are used in conjunction with other procedures such as "packer testing" and coring to evaluate bedrock fractures.

Using the results of the video surveys combined with computer simulations, 3-D models of the subsurface could be created. The videos also provided information used

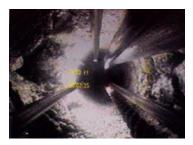


Figure 4-15. Image Looking Down Into a Soil Boring With a Downhole Video Camera

to optimize the placement of well screen intervals in the groundwater monitoring wells that were installed in bedrock.

This work is part of the continuing effort by the IRP to stay involved with the development of technologies that hold the promise of significantly reducing site investigation and long-term monitoring costs.

TRACER STUDIES

In an effort to demonstrate that groundwater contamination in certain areas of Edwards AFB poses little or no threat to off-base receptors, IRP personnel have initiated sophisticated tracer studies. The objective of the studies is to "date" the groundwater beneath Rogers Dry Lake and trace its historical movement. The tracer studies involve the monitoring of three constituents in the site groundwater: tritium, carbon fourteen (C-14), and inorganic minerals.

Radioactive tritium concentrations in the upper atmosphere were elevated during the 1950s due to atomic bomb testing.

Natural precipitation carried some of the tritium into the ground where it migrated into the groundwater. Measurement

Tracer studies are used to "date" the groundwater and trace its historical movement.

of tritium levels in the groundwater can be used to determine if any of the groundwater dates from before the 1950s.

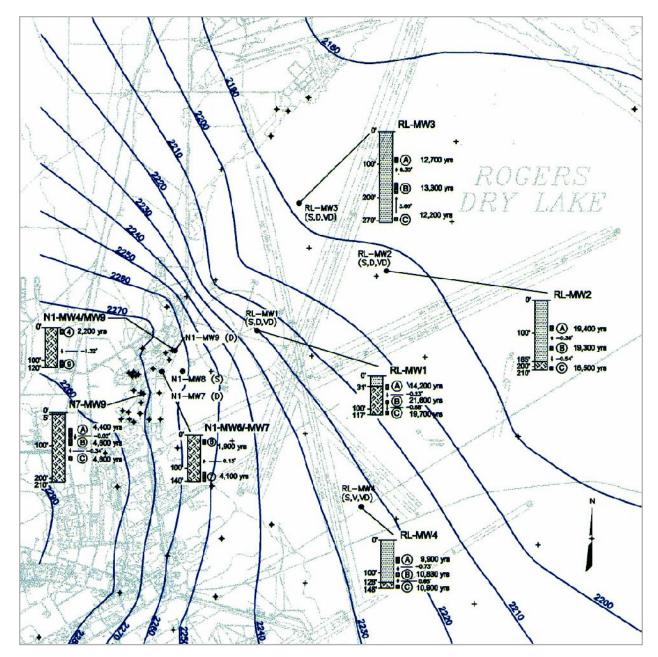


Figure 4-16. Map of Tracer Studies

C-14 occurs in a known ratio to C-12 and decays at a known rate with a 5,700-year half-life. Measuring the level of C-14 in groundwater is also an indicator of the age of the water. The approximate age of the groundwater beneath Rogers Dry Lake is estimated to be 10,000 to 20,000 years. In addition to radioactive species, inorganic mineral concentrations can be used to characterize the groundwater. The concentrations and ratios of various inorganic cations and anions in

the groundwater can be used to relate one body of water to another.

Tracer studies have been particularly useful at OU10 in evaluating the possible threat of contamination to off-base receptor wells. Potential migration of contaminants from sites within Edwards AFB toward the off-base receptors does not appear to be occurring, or the contamination is moving at an extremely slow rate. Thus, the current data indicate that the threat to off-base receptors is very low.

ESTABLISHMENT OF THE BASE ENVIRONMENTAL ANALYTICAL LABORATORY

Edwards AFB is one of the few DoD installations that established our own analytical laboratory to partially support the IRP. The Base Environmental Analytical Laboratory (BEAL) facility has been used to reduce the cost and expedite the analysis of environmental samples.

The on-site analytical laboratory at Edwards AFB has been used to reduce the cost and expedite the analysis of environmental samples.

In addition to establishing a local analytical capability, the BEAL facility has:

- Provided Edwards AFB with a "first look" capability prior to starting any formal monitoring program; and
- Provided an enhanced analytical capability for the Fire Department Hazardous Response Team.



Figure 4-17. The Base Environmental Analytical Laboratory (BEAL)

The on-site analytical laboratory at Edwards AFB can conduct environmental analyses for both organic and inorganic contaminants in support of site investigations, operations and maintenance sampling, and some long- term monitoring programs.

The laboratory has also contributed to the development of "specialized" analyses, including those for:

- 1,4-Dioxane:
- Perchlorate:
- Fuel dating and fingerprinting; and
- JP-4, JP-7, JP-8, and JP-10 speciation.

EVALUATION OF THERMAL OXIDIZERS FOR DIOXIN FORMATION

In June 1996, EMR personnel responded to the concerns of several local citizens regarding the vapor

catalytic oxidizers used to destroy vapors containing chlorinated compounds at one interim removal site.

Specifically, concerns were raised regarding the potential formation and emission of dioxins, since these compounds were known to be emitted from commercial hazardous waste incinerators.

emissions from thermal/

The citizens' concerns made us reevaluate and ask more questions about this particular cleanup method.

To respond to public concerns, Edwards AFB conducted extensive research to develop a dioxin sampling and analysis plan.



Figure 4-18. Testing for Dioxins in a Thermal Oxidizer



Figure 4-19. Collecting Data at an Air Monitoring Station

The USEPA was asked to conduct the vapor testing since they were considered by the citizens to have unbiased expertise.

Initial stack testing of a thermal/catalytic oxidizer at Edwards AFB detected dioxin in two out of three samples at levels above what was expected.

Corrective actions initiated as a result of these data included:

- Shutting down the oxidizer and making operational changes, even though no process was identified to account for the dioxin formation;
- Retesting that showed dioxin levels emitted from the unit were well below proposed regulatory standards; and
- Atmospheric plume modeling to further demonstrate that the emissions from the oxidizer did not pose a health threat to the public.

INVESTIGATION OF HOMESTEAD WELLS

Prior to the 1940s, homesteaders in the Antelope Valley literally created an oasis in the desert by drilling groundwater wells for agricultural and domestic purposes.

Edwards AFB personnel conducted a base-wide effort between 1991 and 1994 to identify potential homestead groundwater wells on the Base. The results of this investigation were as follows:

Homestead laws allowed citizens to acquire 320 acres of public land in desert areas of the country. The key to staking a claim was to make the land productive. The key to productivity was finding water.

- Over 653 inactive water wells were located; and
- Although many of these wells were capped or destroyed when the Base was established, approximately 200 still provided a pathway for contaminants to migrate to the groundwater.

Edwards AFB personnel screened each of the abandoned homestead wells for possible contamination. After the wells were screened, they were capped with locking caps so that they would no



Figure 4-20. Homesteaders Drilling a Water Well

longer provide a pathway to the groundwater.

Following the screening, it was determined that additional intrusive groundwater sampling and analysis would be required for over 60 inactive homestead wells. The results of

the homestead well sampling and analyses at Edwards AFB revealed the following:

 Groundwater in eight separate wells was found to be contaminated, and the sites were listed by the IRP;

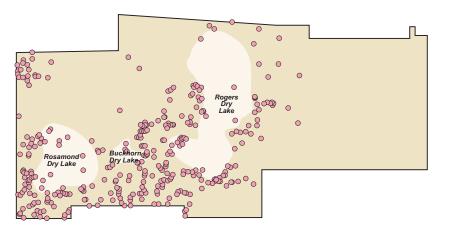


Figure 4-21. Edwards Air Force Base Location of Homestead Wells

- The sites were further investigated as part of a Remedial Investigation phase and found to be clean; and
- Each homestead well is scheduled to be closed according to California Department of Water Resources (CDWR) well abandonment guidelines.

In addition to identifying the contaminated sites, Edwards AFB personnel determined that many of the 280 previously-abandoned wells were not correctly destroyed, and a plan has been implemented to properly close these wells according to CDWR guidelines.

SAMPLING OFF-SITE WELLS FOR PERCHLORATE

Perchlorate represents a new contaminant of concern that was recently identified in groundwater monitoring wells located near the northern border of Edwards

With the very slow rate of groundwater movement, we don't expect any contamination to leave the Base. However, the wells will provide us and the public with peace of mind.

AFB. The contamination originated from the release of ammonium perchlorate, a primary component of solid rocket fuel.

Perchlorate is formed from the dis-association of ammonium perchlorate in groundwater. Ammonium perchlorate is a highly soluble salt, and perchlorate is difficult to treat because of this solubility. In addition, the constituent is slow to degrade, has a low adsorption capacity onto granular activated carbon, and is not easily removed from water via air stripping.

Perchlorate was identified in groundwater monitoring wells near the Edwards AFB north border at concentrations as high as 760 parts per billion (ppb). In 1997, the State of California set the provisional action level for perchlorate at 18 ppb. In 1999, the USEPA calculated a

"Drinking Water Equivalent Level" of 31.5 ppb; that same level is being considered by the USEPA in its development of a Perchlorate Health Advisory. Based upon this information, the public was concerned about the potential migration of perchlorate to off-base drinking water supply wells.

In response to public concerns, we coordinated a joint response between Edwards AFB, the RAB, the California DHS, and the local water purveyors.



Figure 4-22. Sampling Groundwater

Edwards AFB arranged for sampling of the drinking water supply wells located in the communities of North Edwards and Boron. Groundwater samples were collected and analyzed by the DHS. The results of the sampling indicated no perchlorate in the wells.

Edwards AFB has installed eight additional groundwater monitoring wells to provide a better understanding of the hydrology in the North Base area. We also are actively involved in the development of effective treatment methods for perchlorate.

CHAPTER 5 TURNING DATA INTO INFORMATION

Data are turned into useful information when data are collected, organized, and displayed in ways that allow them to be compared effectively and efficiently. Turning data into information that supports decision making is always a challenge, but particularly so for such a large number of sites that generate thousands of data points and hundreds of primary documents. Having useful information instead of just columns of numbers begins with well-planned DQOs; please see Section 4.1 for a longer discussion of DQOs. After DQOs are established, EMR uses several sophisticated techniques to evaluate and compare data and draw information from the data. In this chapter, we highlight our:

- Geographic Information System (GIS);
- Handling of Groundwater data;
- Development of an AFRIMS Integrated Supplemental Database;
- Development of background metals concentrations; and
- · Document management.

THE GEOGRAPHIC INFORMATION SYSTEM (GIS)

The Edwards AFB GIS was planned and developed from the beginning to be a comprehensive base-wide

The Edwards AFB GIS system is continually being expanded and updated.

system incorporating information from many organizations on base. The GIS is continually expanded and updated. Each organization involved in infrastructure or operations is responsible for loading and maintaining its data in the

GIS, and all the data are available for use by base organizations.

The GIS is a valuable asset to EM and the Base; it would be more difficult to understand or change the Base Comprehensive Plan without the base-wide GIS.

EMR uses the GIS extensively and there are enormous benefits. The GIS:

- Shows us building, road, and infrastructure locations which in turn show us where we should not drill:
- Organizes soil boring and well data and chemical analyses by geographic location, making the data instantly available via "point and click";
- Maps and displays contaminant concentrations in soil and in groundwater;
- Helps us see where to place more sample points to fill data gaps;
- Shows us our progress in risk reduction as soil contamination declines and groundwater plumes recede;
- Shows us underground utilities so that we can avoid drilling near them, which would endanger personnel and equipment; and
- Helps us evaluate wind direction, terrain, and road access, and thereby pinpoints the right location for our Pentaborane destruction activities.

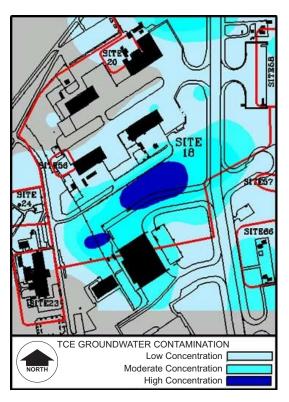


Figure 5-1. Two-Dimensional GIS Map of Groundwater Plume with TCE Concentration Contours

GIS maps are also very helpful to our Command personnel, RPMs, stakeholders, and communities when they are used in presentations.

GIS has enhanced and automated data organization and retrieval, data comparisons, placement of remedial systems, and the resulting early, quick risk reduction. Without GIS, we would have had to produce the results manually at a cost of far greater time and effort. Moreover, when an RPM, a RAB member, or a member of our community can "see" into the subsurface, they can better understand the decisions we make regarding the placement and type of remediation systems.

CREATION OF GROUNDWATER MODELS

We understand the concentration of contaminants in groundwater and the direction and speed of groundwater movement by using simulation programs referred to as "groundwater models." The results of the simulations and the models tell us the locations and concentrations of contamination in the groundwater and where and how quickly it is moving. We can overlay the models onto maps of the corresponding IRP sites using the GIS and "see" the location and movement of groundwater and contamination beneath the sites.

By comparing plume shapes over time, overlaying them on top of each other, we can watch groundwater movement and contaminant migration and see the contamination concentrations decline and recede in response to our risk reduction efforts.

GIS thus turns columns of chemical data into usable information. The information reveals trends and directions in contaminant concentrations, points out areas of high concentration ("hot spots") which are frequently under or near the source of the

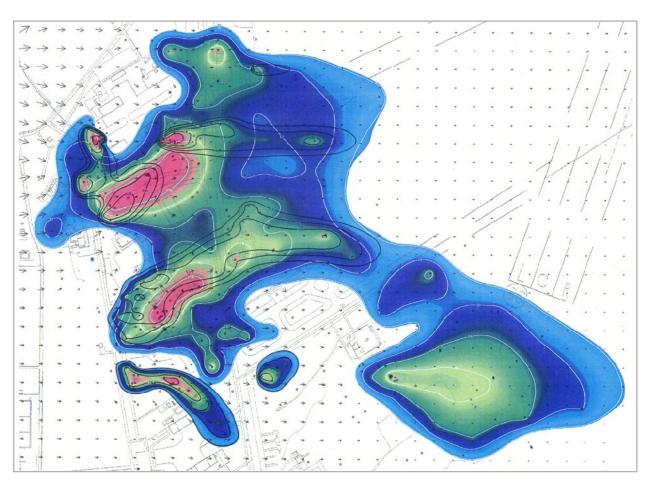


Figure 5-2. Main Base Plume Map

contamination, and predicts migration and the plume's response to cleanup actions.

We use the models, GIS displays, and GIS maps to show us where the aquifer is confined and to predict groundwater concentrations over time. The concentrations are used to predict the effects on local receptors. With the input of additional site conditions, groundwater models can be used in Natural Attenuation (NA) studies to estimate how quickly contaminant concentrations are declining due to natural biological activity and natural conditions.

Here are two examples of our accomplishments using groundwater models:

- We ran a groundwater model for OU1 using a time period of 99 years and discovered that the plume would not migrate very far nor would it get appreciably cleaner in 99 years. Because of the model results, we are considering Institutional Controls at the site and began hot spot reduction efforts.
- At IRP Site 13/133, the groundwater model allowed us to close a landfill much more quickly.
 Preliminary groundwater results downgradient from the AFRL Landfill had indicated the landfill might be a source for the plume beneath it. But the groundwater model clearly indicated that the plume originated upgradient from the landfill and was

merely flowing under it.

Sampling upgradient from the landfill confirmed the model and found the plume's source. We were able to close the landfill site because it did not contribute to the groundwater contamination.

In addition, we use the GIS models and the easy-to-understand graphics at RPM and RAB meetings to describe the subsurface and the movement of groundwater. The maps and displays help the RPMs and others visualize the sites, the interactions in the subsurface, and the distances to potential receptors.

DEVELOPMENT OF AN AFRIMS INTEGRATED SUPPLEMENTAL DATABASE

The Air Force Restoration Information Management System (AFRIMS) is an Air Staff database that tracks crucial financial and phase data at the OU-level for all

Air Force Restoration
Programs. We populate the
AFRIMS database with our
data and the database
provides Command and Air
Staff with, among other
things, a Cost to Complete
and a Schedule to Complete.

We are required to populate and update AFRIMS frequently. Since we also input data to our local project management databases, we were facing Moving towards a single, centralized relational database should eliminate multiple data entry, data entry errors, and inconsistencies in data.

entering data multiple times. We decided to build related databases that would import and export data to and from AFRIMS, thereby:

- Keeping AFRIMS updated;
- Making current data available to all the related databases simultaneously; and
- Requiring us to enter data only once.

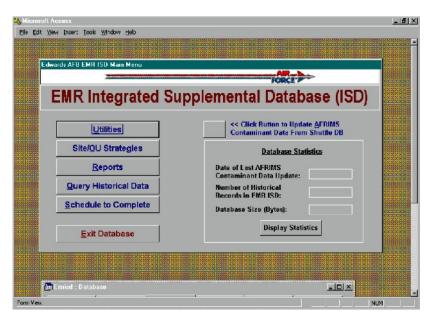


Figure 5-3. AFRIMS Integrated Supplemental Database

Several of the new tools are complete; they are part of the Integrated Supplemental Database (ISD). We are now pioneering sophisticated enhancements to our ISD

We have equipped our ISD with a Site History text field where PMs record a complete history and description of the site in text form: site characteristics, nature and extent of contamination, phase descriptions, decisions reached, primary documents concluded, etc. The benefit is that this is the single version of the site history, it is frequently updated, and the text is instantly retrievable. Now the details and strategies described in the narratives, the Management Action Plan (MAP), and in communications with the RAB or with Command will all be up to date and consistent.

Our most valuable AFRIMS enhancement is the Narrative Writer. The Narrative Writer uses the Site History field and data from AFRIMS and our ISD to create our narratives.

Because of EMR's enhancements, AFRIMS and our ISD will now keep track of the history and evolving strategy at every site. Sites are four-dimensional, with time as the fourth dimension. Almost everything at a site changes with time: technology, public opinion, regulations, agency personnel, the extent of contamination, laboratory methods, detection limits, the nature of the risk and how and where to control it, and the regulatory agencies' approach to risk reduction are just a few examples.

We are linking our Cleanup Requirement Information System (CRIS) decision-support software with our ISD. We will export the ARARs for a site directly to the Site History field of the ISD. In addition, we will import contaminant data from the AFRIMS Relative Risk fields to our ARARs site contaminant list.

We will use the same database concepts to track our potential UXO locations and the application of the Range Rule, if it becomes applicable to Edwards.

DEVELOPMENT OF BACKGROUND METALS CONCENTRATIONS

Using existing data to yield more information is always a better return on our investment than

generating new data. We're always searching for ways to use existing data to yield new information.

Knowing the background concentrations of metals in soil and groundwater is essential to knowing whether and how much to clean up a site. With over 460 Sites/AOCs at Edwards, determining the background metals concentrations of each site and AOC could be expensive and time consuming. The Antelope Valley is an area rich in metals and water-soluble metal salts. In OU4, naturally occurring levels of beryllium and arsenic are up to 100 times higher than regulatory limits.

How could we get background metals concentrations at a reasonable cost over such an expansive area? We have thousands of sample results indicating soil and groundwater metals concentrations; many of the samples were collected at locations that were not contaminated. Could we use those results?

With the RPMs, we developed a plan for using existing data to calculate background metals concentrations without having to obtain a single new sample! We pulled from our database the concentration of each metal in every uncontaminated soil sample on base. We even developed a plan with the RPMs whereby we could use the metal results from soils contaminated with petroleum but nothing else.

Our experts in statistics met with the regulatory agencies' experts and developed the statistical protocols we used to calculate the background metals concentrations from

Several sites where metals were present immediately qualified for NFI status.

our existing data. The RPMs approved the calculations and the resultant background concentrations. The result is that we have effectively conducted the background studies for hundreds of sites without taking a single new sample. Background studies for 469 IRP sites at only \$5,000 per site would have cost us \$2,345,000. We are also generating large cost savings because we are not required to clean up metals sites to levels cleaner than background. Saving just 40 hours a year in negotiating background levels avoids an additional \$938,000 expense.

In 1995 we produced our Programmatic
Background Metals Procedure Document. With
background concentrations now known over a wide
expanse of the Base, several sites immediately
qualified for NFI status. At sites still under
investigation or cleanup, we will take no further action
for metals unless metals concentrations are above
regulatory limits and above the background levels.

Other EM Divisions have used our Background Metals documents. The Quality Division received a Regional Water Quality Control Board Order to monitor wells near evaporation ponds at South Base and was concerned whether some "high" metals concentrations would cause the Water Board to act. The South Base Background Metals in Groundwater document showed the Quality Division that the metals concentrations, while in some cases above regulatory limits, were below background levels.

DOCUMENT MANAGEMENT

EMR generates more than 100 documents each year for review and comment by the Air Force and the RPMs. Even the remote possibility of misplacing or omitting the comments from any one of our dozens of reviewers concerns us, so we physically track the locations of the documents and the review copies. We know where a document is in its review cycle, and we



Figure 5-4. Document Organization in the IRP Library

physically track the correspondence that contain reviewers' comments. We show in a table in our Monthly IRP Status Report the comments that have been received, which comments are due, and by what



Figure 5-5. Older Hard Copy Documents Being Scanned into Electronic Files.

date. Our document management is effective, and the tracking task is done manually.

We researched the use of document management software. GIS personnel were experimenting with a document management software package that tied the graphic information to reports and other textual information. Other document management systems were also investigated. On paper the cost savings seemed impressive, but in reality the cost of the hardware and software, the changes to contract deliverables, problems in developing database security, the limitations of moving data across the DoD Internet security barriers, and the wide range of capabilities of the few organizations that review our documents made the investment in a fully-functional document management system too costly and risky. The mission of EMR is to protect human health and the environment; the expenditures of funds and human resources to develop such a system did not seem to be a wise investment.

If and when the Communications Squadron or some other organization at AFFTC develops a document management system, EMR will evaluate its usefulness and adopt it if it is cost effective. For now documents are received in Adobe Acrobat so they can be accessed electronically. Older documents that are used frequently have been electronically scanned and can be read with Adobe Acrobat. The older documents are maintained as images. Optical Character Recognition (OCR) software can convert scanned document images into text; however, we have determined that it would be very difficult to ensure that OCR'ed documents maintain the exact wording that was approved by the RPMs. Maintaining the documents as images allows us to avoid that problem.

CHAPTER 6 CLEANUP AND RISK REDUCTION METHODS

The goal of the Air Force's Restoration Program is to protect human health and the environment by locating and reducing risks. The Program Management objective is to reduce risk to the point of securing site closures as quickly as possible and to do so with the wisest use of and highest return on program resources.

In Chapter 2, we described Edwards AFB's strategy for risk reduction and the steps we take across the Base to implement the strategy. One measure of the return on investment is the number of sites closed. As of December 1999, Edwards AFB has *closed*, via findings of NFI and NFRAP, **265 Sites/AOCs**, or **57% of our sites**. In this chapter, we highlight the innovations and initiatives we use to reduce risk and close sites.

Existing and new technologies are a big part of the risk reduction program. The Edwards subsurface can be difficult to clean up—in several areas, there are chlorinated solvents in fractured bedrock. We seek better and better technologies to help us reduce risk. That aim matches our role as a Test Center—we test and refine new and old technologies and export our lessons learned to other sites at Edwards, and to the Air Force and the larger restoration community. We work to determine the most effective way to reduce

risk while making the wisest use of our resources.

We are most proud of the relationship we have with the surrounding communities through the RAB and the new technologies we are putting in place to accomplish cleanup. At sites where contamination levels are below action levels or where enforceable institutional controls can be used to prevent contact with contamination, EMR writes a Site Summary Report justifying a finding of NFI, and we close the site. At other sites, however, the risk posed warrants additional action.

This chapter highlights 25 risk reduction initiatives and innovations. In summary, they are:

- Using CERCLA's flexibility: Time-Critical Removal Actions
- · Base-wide Initiatives
 - Natural Attenuation
 - Background Metals Studies
 - Chemical Warfare Materiel Management

· Shallow Soil Risk Reduction Methods

- Underground Storage Tank Removal
- Soil Excavation
- Establishment of a Soil Treatment Farm
- Drill Cuttings and Clean Overburden Management
- Beryllium Burial

· Established Risk Reduction Technologies

- Bioventing
- Dual Extraction
- Bioslurping
- Mobile Free-Product Recovery
- Air Sparging/Soil Vapor Extraction

• Methods Under Test

- Cometabolic Biodegradation of Trichloroethene
- Oxygen-Releasing Compounds
- In-Well Vapor Stripping
- Biofiltration
- Internal Combustion Engines

• Other New Techniques

- Micropurging Groundwater Wells
- Supervisory Control and Data Acquisition System
- Use of Skid-mounted Equipment

Successful risk management involves more than implementing multiple technologies. The other strategies that have made our risk reduction and closure program a success are:

- A bias toward action, not study. Risk reduction and closure are the central tenets of our program; 46% of the FY99 budget was expended on new and continuing remedial actions.
- Efforts toward a shared understanding in the stakeholder team that it is seldom practical and rarely possible to reduce risk to the point where contaminant concentrations are at pristine levels.
 EMR's task is to accurately measure the risk and reduce it as effectively as possible.

- A combined team effort by the IRP staff, the RPMs, the RAB, and the larger regulatory community.
- The resourcefulness, creativity, and persistence of the team to learn from each other and from the larger community.
- EMR's willingness to try experimental techniques and alternate methods. EMR invites and encourages others to refine their technologies at Edwards AFB sites.

A WILLINGNESS TO TRY EXPERIMENTAL TECHNIQUES

EMR tracks the development of new technologies and is always willing to field test experimental technologies that may provide cost-effective risk reduction at Edwards and other Air Force Bases once the lessons learned are

shared. EMR's technology test program delivers these benefits:

 We encourage the efforts of the private sector to find less expensive and more effective risk reduction methods; Edwards AFB has demonstrated the flexibility of CERCLA's Time-Critical Removal Actions .

- We maintain an expert staff that is at the forefront of the remedial technology field;
- We provide significant dividends to the private sector and other DoD facilities by demonstrating the applicability and limitations of new technologies; and
- We have determined that several technologies work very well.

With such a varying lithology, including several areas where the contaminants are located in fractured bedrock, Edwards AFB is an ideal location for testing experimental remedial technologies.

USING CERCLA'S FLEXIBILITY TO REDUCE RISK

Edwards AFB has demonstrated the flexibility of CERCLA as the preferred regulatory mechanism under which risk reduction actions can be planned, reviewed, implemented, and documented in an expedited manner. We highlight these three examples:

- Pentaborane destruction;
- · SRAM motor removal; and
- · Inactive landfill closure.

PENTABORANE DESTRUCTION

As the saying goes, "timing is everything." That can be especially true when responding to the risk from 400 aging cylinders of the highly-energetic rocket fuel pentaborane. Pentaborane was developed in the late 1950s and burns with tremendous heat when exposed to air.

Approximately 200,000 pounds of pentaborane were stored at AFRL in 400 steel cylinders for the past 30 years.

Inspection indicated that many of the cylinders did not meet the specifications for continued storage or shipment over the highway.

Cylinder failure



Figure 6-1. Steel Cylinders of Pentaborane

could prove lethal. On-site destruction was considered the most viable treatment option.

EMR determined that CERCLA protocols offered the most flexible and expeditious regulatory option for handling the destruction of the pentaborane. The CERCLA process was used because:

- An EE/CA was an excellent means of planning the destruction, obtaining regulatory and public buy-in, tracking the activity, providing for protection of public health, and avoiding long delays associated with permitting; and
- A Time-Critical Removal Action could rapidly address the destruction of the cylinders that were found to be corroded or otherwise damaged.

Within the CERCLA process, we developed a

Diligence, safety, and no surprises were the rule on this operation. Project Plan to transport and destroy the eight most heavily-damaged cylinders at a remote, specially-chosen site at AFRL. To protect the safety and health of the project team, on-site personnel, and the public, the Project Plan demanded specific procedures and extensive precautions, including restrictions on wind speed and direction. We destroyed the eight damaged cylinders in three smoothly-executed burn events.

It is important to see that while the pentaborane destruction program was not eligible for IRP funding, the CERCLA process could be used for the risk reduction program funded by the Quality Division or other budgets.



Figure 6-2. Controlled Open Burning of Corroded or Damaged Pentaborane Cylinders

SHORT-RANGE ATTACK MISSILE (SRAM) REMOVAL

SRAM rocket motors and rocket fuel are inherently unstable. Upon discovering an old SRAM motor stored in relatively poor condition at AFRL, immediate action was required to reduce the risk and ensure the safety of site personnel. EMR proposed a Time-Critical Removal Action be implemented under CERCLA.

An EE/CA was prepared and reviewed by the regulatory agencies and the public. The EE/CA called

No permits were necessary under CERCLA, which further expedited the procedure. for using a remotelycontrolled forklift to transport the SRAM to a safe distance away from the buildings where it could be safely destroyed. The destruction occurred safely and without incident. No permits were necessary under CERCLA, which further expedited the procedure. The entire removal action was well documented and thoroughly reviewed by all involved.

It should be noted that this activity was also not eligible for IRP funding. However, regulatory and funding decisions can be considered separately. CERCLA processes can be used for removal actions that are not funded by the IRP.

INACTIVE LANDFILL CLOSURE

Closing a permitted landfill under CERCLA authority rather than the more-prescriptive RCRA regulations saves substantial time and resources. At Site 13, the cost savings realized by the landfill closure under

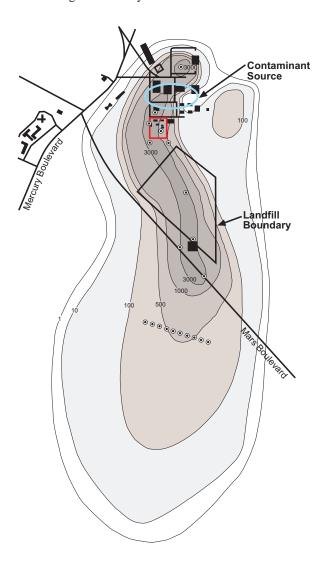


Figure 6-3. Inactive Landfill Groundwater Contamination

CERCLA vs RCRA were estimated at \$7 million to \$10 million.

EM first planned to close the landfill under RCRA because:

- The landfill ended operation in 1990 when TCE and perchloroethene were detected in the groundwater under it; and
- The landfill was permitted by both state and county agencies as a solid waste disposal facility.

We weren't happy with the RCRA procedural requirements for a landfill cap and RCRA's mandated monitoring given the estimated small risk to human health and the environment. We also wanted to avoid the inefficiency of simultaneous investigation and cleanup efforts because OU4, including Site 13, would be investigated and cleaned up by EMR under CERCLA.

- Using groundwater models, we developed strong evidence that:
- The solvents in the groundwater under the landfill were from an upgradient source unrelated to the landfill; and
- There were no releases from the landfill.

Based on this evidence, we petitioned the regulatory agencies to rescind the landfill permits and allow us to close the landfill under CERCLA. The regulatory agencies agreed. When closure is complete, the cost savings by avoiding investigating and closing the landfill under RCRA are estimated to be \$7 million to \$10 million.

BASE-WIDE INITIATIVES

This section discusses the four risk reduction programs implemented at Edwards AFB that apply throughout the Base:

- Natural Attenuation Programs;
- Background Metals Documents;
- Management of Unexploded Ordnance (UXO); and
- Management of Chemical Warfare Materiel (CWM).

NATURAL ATTENUATION

Natural Attenuation (NA) is occurring all the time at our sites, sometimes slowly, often more quickly. NA includes all these forces that act to reduce the risk,

Implementing
Monitored Natural
Attenuation as a remedial alternative is not a
"do nothing" action.



Figure 6-4. Microorganisms Like These are Responsible for Natural Attenuation

toxicity, and mass of contaminant releases in the subsurface:

- Dispersion;
- Dilution;
- · Adsorption; and
- · Biodegradation.

At several sites, we are monitoring natural attenuation and watching the contaminant concentrations decline. Monitored Natural Attenuation (MNA) has provided us an effective remedial alternative at sites where active

remediation is not practicable from a technical or cost standpoint.

Implementing MNA as a remedial alternative is not a "do nothing" action. Effective use of MNA requires us to perform:

- Periodic sampling and analyses of the groundwater;
- Statistical evaluations of the contaminant concentrations:
- Groundwater fate and transport modeling; and
- · Risk assessments.

Extensive monitoring of a site is necessary to verify that NA is occurring at a rate that will reduce the risks to an acceptable level in a reasonable amount of time. When the contaminant concentrations are reduced to a level where they can't be efficiently removed and no longer pose a threat to human health and the environment, we turn off the cleanup equipment and let nature continue the cleanup job.

BACKGROUND METALS STUDIES

Management of risk also means comparing contaminant concentrations against the naturally occurring background levels. Recognizing that metals can occur naturally at concentrations above regulatory limits can save significant effort and cost when evaluating risk and cleanup needs. Such was the case at one of our sites where background levels of beryllium and arsenic were 100 times the Preliminary Remedial Goals (PRGs). We saved the time and resources that might have otherwise been spent on unnecessary cleanup.

We recognized that concentrations of naturally occurring metals are sometimes above regulatory limits and saved a significant effort and cost by avoiding an unnecessary cleanup.

In Chapters 2 and 5 we described our Background Metals project during which we conducted a rigorous statistical evaluation of our background metals concentrations and established our final background levels, including proving our naturally-high levels of beryllium, arsenic, and aluminum. From the studies, we published

our Background Metals Documents.

Before we begin remedial action for metals, site concentrations must be:

- · Above background levels; and
- · Above PRGs.

The previously-published Background Metals Documents save us from determining background contaminant concentrations separately for each site.

CHEMICAL WARFARE MATERIEL (CWM) MANAGEMENT

The Edwards AFB IRP is unique in the Air Force in that it is faced with cleaning up several atypical contaminants, including CWM. EMR has assumed the lead role in addressing and managing the risks posed by CWM. Our initial efforts to locate potential CWM burial areas at Edwards AFB have focused on:

· Archival research;

- Review of aerial photos;
- Interviews with former Base employees; and
- Use of remote airborne sensors.

We discussed in earlier chapters the data collection

A total of 25 potential CWM sites and one potential biological simulant site were discovered through archival research.

methods of archival research, aerial photo review, and "old timer" interviews. In this chapter we'll cover other aspects of CWM risk management.

Our approach to CWM emphasizes lowering the potential immediate risk to project personnel, employees, and residents as well as lowering the long-term risk to the environment. Common sense approaches combined with strict health and safety precautions are emphasized during all ground-based activities at CWM sites.

Once suspect areas are identified, we proceed in this order:

- Ground-based, non-intrusive geophysical methods are used to scan the area for buried metal objects;
- State-of-the-art monitoring devices are used on the ground surface to detect the presence of CWM and degradation products and ensure the safety of nearby personnel.

The following example describes our methods.

Evaluation of CWM at Site 426

- During archival research, we located maps dated February 1942 and May 1944 that showed the location of a "Toxic Gas Yard."
- Ground-based geophysical surveys delineated four trenches, each 15 feet wide by 150 feet long.
- We drilled four soil boreholes outside the trench boundaries and collected soil samples; no evidence of CWM or degradation products was found.
- We conducted active and passive soil gas surveys over the four trenches; the results were inconclusive, therefore, further study was planned.
- We prepared a sampling plan for long-term monitoring of soil and groundwater.

- We prepared an Analysis of Alternatives to evaluate potential removal alternatives, including:
 - In-situ vitrification;
 - Excavation; and
 - Capping and monitoring.
- We are evaluating the removal alternatives further while preparing an EE/CA.

We developed and followed a strict notification protocol:

- ATSDR was notified of the possible presence of CWM;
- The RAB was briefed several times;
- Several articles on CWM were published in the Report to Stakeholders; and
- Local media were briefed many times.

Although no final CWM removal actions have been approved or implemented, we are actively tracking the development of technologies for CWM destruction or containment. Our emphasis is on techniques that most safely, quickly, and cost effectively reduce the risk of exposure to project personnel, employees, and residents.

UNEXPLODED ORDNANCE MANAGEMENT

The risks at Edwards AFB from unexploded ordnance occur in three forms:

- Individuals come onto our property and take UXO items home as souvenirs;
- During site investigations and cleanups, we find unexploded bombs (three unexploded bombs have been uncovered at IRP sites so far); and
- Buried constituents can contaminate our soil and groundwater.

We have taken advantage of the skills we developed during the search for CWM to search our range and our sites for UXO and reduce the risks. We've already seen a large return from our investment in CWM research:

 While conducting archival research for CWM, we noticed that the same records showed the locations of targets and bomb drop areas on our ranges;

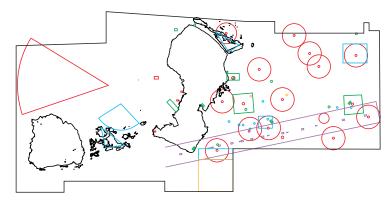


Figure 6-5. Edwards Air Force Base Known Target and Bomb Drop Areas

- We learned that UXO is known to generally fall within two miles of practice targets, or within four miles if bomb fins are being tested;
- We created maps showing known target and bomb locations and placed the maps on our GIS; and
- While conducting helicopter-borne geophysical surveys for CWM, we found that the sensors could also pinpoint on the ground surface metal objects weighing as little as 30 pounds.

The UXO location information cost us nothing because we were already conducting CWM research. It is essential for our own safety and the conservation of our critical habitat that we use non-intrusive methods to locate UXO. Ground-based geophysical surveys often require removing all vegetation from an area where the surveys will be performed. This could endanger our desert tortoise critical habitat and require us to enter into consultations with the U.S. Fish and Wildlife Service (USFWS).

SHALLOW SOIL RISK REDUCTION METHODS

The five achievements and initiatives discussed in this section apply to reducing risk in relatively shallow soil. Our primary method for handling shallow soil has been to excavate the contaminated soil and transport it to our on-base Soil Farm for remediation, if feasible.

The potential exposure pathways from shallow contaminated soil are through dermal contact, dust inhalation, and incidental ingestion. The potential human receptors are Air Force employees and contractors digging in or moving the soil. We completely eliminate the risks of exposure by excavating and transporting the soil to our Soil Farm on base or to treatment and disposal facilities off base.

We backfill excavations with clean soil, often cleaned-up soil from our Soil Farm.

UNDERGROUND STORAGE TANK REMOVAL

Records indicate that 571 Underground Storage Tanks (USTs) were installed at Edwards AFB over the years. EMR manages the UST removal and risk reduction program. We have removed **333 USTs** and considerably reduced the risks associated with leaving them as sources of future contamination. Of the remainder, we have:

- Determined that 212 USTs cannot be located; many are believed to have been removed sometime in the past;
- · Abandoned four USTs in place; and
- Upgraded 26 active USTs to bring them into full compliance with new construction and monitoring standards.



Figure 6-6. UST Removal

With the agreement of our RPMs and the endorsement of the county regulatory agencies, EMR, under the jurisdiction of the Regional Water Quality Control Board–Lahontan Region, manages the cleanup of leaking USTs that affected groundwater.

We address groundwater contamination from the USTs using "hot spot" focused Interim Removal

Actions or we will include the cleanups within the larger OU-wide remedial action after the Record of Decision is signed in 2004 or 2005.

SOIL EXCAVATION

We manage the cleanups of a subset of petroleum USTs that are under the jurisdiction of the Kern County Environmental Health Services Department. Led by Kern County, the cleanups do not require EE/CAs or Treatability Study Work Plans. We prepare Remedial Action Work Plans, integrating the cleanups into our overall cleanup strategy and wisely using resources to reduce risk most effectively.

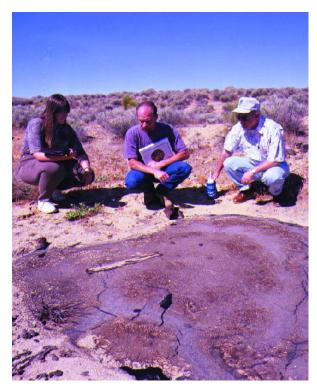


Figure 6-7. Tar Pit Discovered by a RAB Member and Subsequently Cleaned Up

To make the cleanups more effective and efficient, we use a hierarchy of simple, presumptive remedies and rules under which each remedy is most effective. Excavation and on-site treatment are the most expedient and cost-effective remedies for shallow, fuel-contaminated soil where groundwater is not affected. We call these shallow excavation projects "scoop and runs" and they involve:

- Excavation of affected soil;
- Use of immunoassay field test kits to screen the excavation to determine when all contaminated soil has been removed;
- Collection of confirmation samples;
- Treatment of the soil at our on-base Soil Farm or at off-base recycling facilities; and
- Backfilling the excavation with clean soil.

CERCLA doesn't have to be conducted one site at a time or even only with related CERCLA doesn't have to be conducted one site at a time or even only with related sites together.

sites together. As an example, in 1997 we were planning to remediate five sites with presumptive remedies ("scoop and run") and other simple remedies (i.e., soil stabilization with cement, and tar recycling). The RPMs approved our going directly to the development of the Work Plan. We wrote a single **Remedial Action Work Plan for five sites** (Sites 78, 79, 89, 95, and 100). It was approved, the work was accomplished, and all the sites were designated NFI at the same time in a single visit by RPMs.

ESTABLISHMENT OF A SOIL TREATMENT FARM

Established in 1995, the Edwards AFB Soil Farm can measure success by the truckload. The facility cleans

Figure 6-8. Edwards Air Force Base Soil Farm

fuel-contaminated soil using ex-situ bioventing. The treated soil can be used as fill dirt almost anywhere on base

The Soil Farm has operated at 95% of full capacity and treats an average of 1,000 tons of dirt a year. With its ability to return soil to us, it paid for itself very quickly. We no longer had to buy fill dirt from off base, nor pay to have soils treated or disposed of off site. The annual O&M cost is roughly \$160,000, which is about equal to what we would pay to transport, treat, and dispose of the soil. But the benefits of our Soil Farm are that it:

- Cleans the soil and reduces the risk that the soil will be a continuing source of contamination;
- Eliminates the liability from off-site transportation and disposal; and
- Provides a ready source of clean fill dirt.

The Edwards Soil Farm is one of only four such facilities in the state. At capacity, it holds 5,000 cubic yards of soil stacked in 10-foot high piles. Only soil we generate can be treated here.

In recent months, nearby commercial vendors have finally begun offering soil treatment at prices that compete with our Soil Farm, so the facility will be phased out. However, it is important to remember that for three years, it offered us a risk-free treatment option at a very reasonable cost.

DRILL CUTTINGS AND CLEAN OVERBURDEN MANAGEMENT

Our PMs recognized early in the program that significant treatment and disposal costs could be

avoided if alternatives could be found for handling the roughly 100 cubic yards per year of drill cuttings and clean overburden generated by the IRP. We wrote our "Management Plan for Investigative-Derived Waste" (IDW) in 1992. The Plan received agency approval for these IDW procedures:

 Soil from borings is staged, sampled, analyzed, and used for daily landfill cover at the base landfill, if it is clean;

- Petroleum-contaminated drill cuttings were sent to our Soil Farm and now will be sent off base for treatment; and
- Solvent-contaminated IDW is sent off base for disposal.



Figure 6-9. Managing IDW at a Drilling Site

Reusing drill cuttings as backfill or as daily cover avoids manifesting, transporting, treating, and disposing of soil that is clean, and avoids the costs of clean backfill and landfill cover.

BERYLLIUM BURIAL

In 1995 we discovered elevated levels of beryllium in shallow soils at two sites in OU4 and gave the sites high priority because of beryllium's toxicity. To expedite risk reduction, we followed these steps:

- We prepared an EE/CA and proposed on-site burial of the soil as the best alternative;
- The EE/CA showed that burying the affected soil on site would:
 - Eliminate the potential risk of exposure;
 - Be more cost effective than off-site transportation and disposal;
 - Pose no threat to the site groundwater; and
 - Provide a permanent solution requiring no further action and no long-term monitoring; and
- We received regulatory agency and public comments.

After receiving public comment and agency approval, we implemented the proposed on-site burial. We placed the soil into an excavation, placed clean backfill and a plastic liner over the soil, constructed a fence around the burial, and restored the site to match the surrounding landscape.

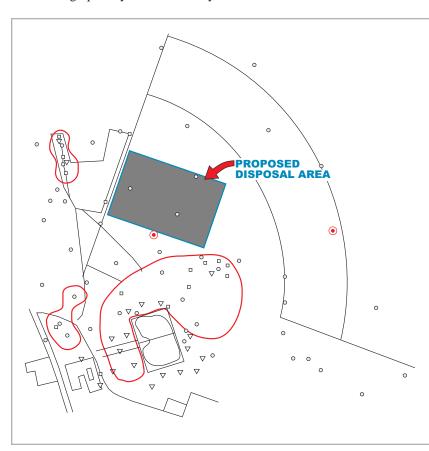


Figure 6-10. Beryllium-impacted Soil Disposal

ESTABLISHED RISK REDUCTION TECHNOLOGIES

Most of the remediation technologies in place or planned at Edwards AFB have been implemented as IRAs or Treatability Studies. IRAs provide a means of addressing site risk more quickly than the traditional CERCLA approach, which relies on establishing a ROD before any remedial actions can begin.

Bioventing, Dual Extraction,
Bioslurping, and Air Sparging are
now generally considered to be
established, proven methods for
addressing contaminated soil and
groundwater and reducing risk. As
discussed in the following section,
some of the methods were
considered innovative five years
ago, and Edwards AFB often
served as a test bed for validating
these approaches.

BIOVENTING

In 1993, AFCEE began a nationwide initiative at Air Force installations to evaluate Bioventing and chose over 135 sites at Using Bioventing, we closed Site 43 in only two years!

48 installations throughout the country to test the technology. The technology was targeted at vadose zone soils contaminated with petroleum hydrocarbons such as diesel fuel. Bioventing systems were installed at three sites (Sites 43, 65, and 66) in OU1 at Edwards AFB. A typical Bioventing installation includes:

- Installing shallow wells in the contaminated soil area;
- Using a small blower to inject ambient air into the subsurface through the wells; and thereby
- Providing oxygen to naturally occurring microorganisms in the subsurface which convert petroleum into carbon dioxide and water.

Bioventing has proven to be a successful tool for risk reduction at sites with shallow soil contamination at Edwards AFB. At Site 43, a petroleum UST site, a Bioventing system was installed and began operation in September 1993. By 1995, we had met the cleanup objectives. A request for site closure was submitted to Kern County in 1996, and the Bioventing system was shut down and moved to another location on base.

Bioventing is a successful risk reduction tool at sites with shallow soil contamination at Edwards AFB:

- In 1999, nine Bioventing systems were installed and are operating at eight sites, including five sites at OU2;
- At Site 5 in OU2, Bioventing reduced soil contaminant concentrations to the required levels after only one-and-one-half years of operation;
- The cleanup occurred over two-and-one half years sooner than originally predicted;
- Typical costs to implement a Bioventing system are between \$10,000 and \$20,000; and

 Monitoring requirements are only annual or semiannual respiration testing, which involves collection and analysis of soil gas for oxygen,



Figure 6-11. Ceremony to Shut Down Bioventing System at Site 43

carbon dioxide, and petroleum hydrocarbon concentrations.

After a former UST location at Site 5 was cleaned up much sooner than predicted, we determined a way

When Bioventing sites are near each other, it may be cost effective to leave the equipment where it is and run air lines to neighboring sites.

to get even more from our investment. We realized we could run air lines from that location to another location nearby and begin remediation without moving the Bioventing equipment. Running an air line is much cheaper than running an electrical line. We are able to run the air line on the ground surface. Electrical line would

have required trenching. We estimate a labor and materials cost avoidance of \$15,000.

DUAL EXTRACTION

Edwards AFB was one of the first installations in the Air Force to recognize the benefits of Dual Extraction as a means of addressing contamination in the saturated and unsaturated zones simultaneously. Dual Extraction involves the simultaneous extraction of both groundwater and soil vapor from a single well.

Dual Extraction is:

- Excellent for the removal of contamination in tight lithologies;
- Effective for rapidly addressing "hot spots"; and
- Capable of increasing the contaminant mass removal rates in fractured bedrock.

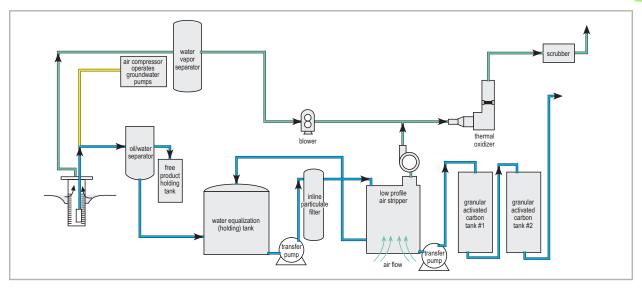


Figure 6-12. Line Diagram of Dual Extraction System

Groundwater contaminant concentrations were reduced to MCLs within two years at Site 45 using Dual Extraction, five years sooner than estimated using conventional techniques.

At Site 45 in OU1, Dual Extraction was applied in the source area, and groundwater contaminant concentrations were reduced to MCLs within two years compared to an estimate of seven years using conventional pump-andtreat methods.

EMR's Dual

Extraction method uses a downhole groundwater pump to extract groundwater. A vapor extraction system attached to the well simultaneously removes soil gas. Both the extracted groundwater and soil vapor are treated at the surface and properly discharged.

BIOSLURPING

In 1995, AFCEE began its program to validate Bioslurping as a valid remedy. The Bioslurping tests

Site 24 was an AFCEE Test Bed for validating Bioslurping. conducted at Site 24 in OU1 at Edwards AFB were a key part of AFCEE's program.

Bioslurping removes floating free-phase hydrocarbons, such as jet fuel, from groundwater. The process consists of the following:

- A tube or "straw" is inserted into an extraction well so that the tip is at the interface between the fuel and groundwater; and
- A vacuum pump at the surface applies suction to

the straw to extract the fuel and minimize the amount of water recovered.

The six-month Treatability Study in 1995 was successful in reducing the amount of freephase product. Free-product
thickness was
reduced from four
feet to a few
inches!

- The evaluation was extended for two years and expanded to six extraction wells;
- Approximately 14,000 gallons of JP-4 have been removed from the site to date using Bioslurping; and
- The thickness of the floating free-phase product was reduced from roughly four feet to a few inches.

MOBILE FREE-PRODUCT RECOVERY UNIT (MFRU)

Removing floating petroleum product from the groundwater is a prerequisite to any long-term risk reduction action.

EMR heard about a solar-powered Mobile Free-Product Recovery Unit (MFRU) in use at George AFB. In 1994, we purchased and tested a similar unit.





Figure 6-13. A Mobile Free-Product Recovery System

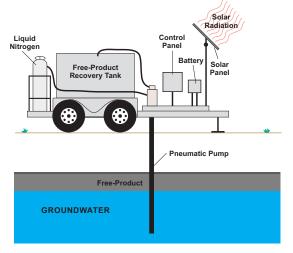


Figure 6-14. Mobile Free-Product Recovery System Schematic

We bought another MFRU in May 1995 and a third, more versatile unit in August 1996. Through 1998, roughly 20,000 gallons of fuel have been "slurped" off the groundwater in OUs 1 and 8. When a technology removes 20,000 gallons of fuel, it becomes difficult to calculate the cost avoidance because conventional technologies couldn't remove this volume in 30 years! It is reasonable to assume that

the cost avoidance over a 30-year period is very large.

The MFRUs are:

- Self-contained, trailermounted;
- Powered by a combination of batteries and solar panels;
- Connected to free-product recovery pumps actuated by nitrogen or compressed air;
- Designed with pumps that remove only floating product; and

Mobile Free-Product Recovery Units have proven to be one of the most successful examples of the innovative technologies tested and implemented at Edwards AFB.

 Equipped with a small product storage tank to collect the free product; when the tank is full, the unit shuts down.

Mobile Free-Product Recovery Units can be quickly moved to any well. Because no outside power source is required, the Mobile Free-Product Recovery Units can be quickly moved to any well where free product is

present and can be operational within hours. All three units are now powered by compressed air, thus eliminating the cost and labor of changing out empty nitrogen bottles.

AIR SPARGING/SOIL VAPOR EXTRACTION (AS/SVE)

AS/SVE is a proven technology used to remove volatile organic compounds (VOCs) from the groundwater and is considered preferable to Pumpand-Treat methods. The technique has been effectively used at Edwards AFB since 1997 when it was first tested at Sites 11 and 17 in OU1.

AS/SVE is described as:

- A remedial system that is most effective in alluvial aquifers with relatively shallow groundwater; and
- A process that injects air into the subsurface through vertical or horizontal wells and strips VOCs from the groundwater in the zone of the sparge wells.

AS/SVE works by forcing air into the groundwater. The resulting bubbling action strips volatile organics from the liquid phase into the vapor phase. When the bubbles reach the groundwater surface, they pop and VOCs are transferred into the soil where they can be extracted via the SVE system.

AS/SVE is less expensive and more reliable than Pump-and-Treat Technologies and promotes biodegradation of contaminants.

AS/SVE provides the advantages of:

- A reduction in groundwater contaminant concentrations that occurs in-situ; no groundwater treatment is required at the surface;
- Less energy required than in ex-situ treatment methods; and
- Reduced capital and O&M costs relative to Pumpand-Treat technologies.

AS/SVE provides the additional benefit of aerating the aquifer which promotes biodegradation of contaminants.

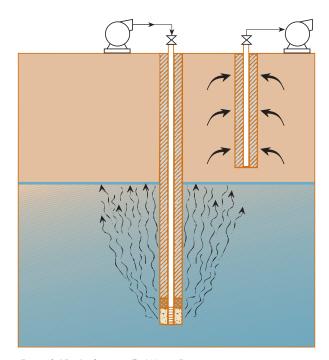


Figure 6-15. Air Sparging/Soil Vapor Extraction

EXPERIMENTAL TECHNIQUES

The six experimental techniques presented in this section are being or have been evaluated at Edwards AFB. The testing is often conducted as a cooperative effort between Edwards AFB and outside organizations such as AFCEE or a university. The technologies are presently considered experimental since their full-scale effectiveness and implementation have yet to be established, and there are still questions about whether the methods will work in the hydrogeologic conditions at Edwards AFB.

COMETABOLIC BIODEGRADATION OF TRICHLOROETHENE

Cometabolic Biodegradation of TCE is one of the most promising of the innovative remedial technologies tested at Edwards AFB. The demonstration at Site 19 in OU1 was a cooperative effort between the U.S. Air

The TMO enzyme causes an in-situ reduction of TCE in groundwater.

Force, USEPA, Stanford University, and Oregon State University and consisted of:

- Mixing small amounts of groundwater with hydrogen peroxide and toluene;
- Reinjecting the mixture into the contaminated aquifer; and
- Monitoring with a network of monitoring wells.

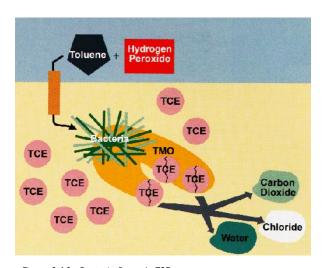


Figure 6-16. Bacteria Degrade TCE

Indigenous aerobic bacteria use the oxygen as "air" and the toluene as "food." The bacteria produce an enzyme called Toluene Monoxygenase (TMO), which degrades the TCE in the groundwater.

Here are the results at Site 19:

- Successful reduction of TCE concentrations from approximately 1,100 ppb to less than 30 ppb;
- Formation of the nonhazardous byproducts carbon dioxide, water, and free chloride; and
- Toluene degradation rate of 99.98%, leaving residual toluene levels in the treatment zone

boundaries of only 1.3 ppb.

Cometabolic degradation was very successful and has several advantages over traditional Pumpand-Treat, including lower cost and faster remediation. We wrote several papers about the test program, and the results were provided to other installations.

The Cometabolic
Biodegradation
demonstration is one of
several partnering initiatives in the IRP. Other
partnering efforts have
been undertaken with
AFCEE, the Army Corps of
Engineers, Battelle Pacific
Northwest National
Laboratory, JPL, NASA,
AFRL, and the U.S.
Geological Survey.

OXYGEN-RELEASING COMPOUNDS (ORCs)

New risk reduction technologies have focused on insitu methods that avoid removing the contaminants from the subsurface and treating them aboveground.

In-situ biodegradation methods only work well when there is ample oxygen in the groundwater.

ORCs promote the biodegradation of dissolved petro-leum hydrocarbons in groundwater.

Oxygen concentrations and the rate of biodegradation can be increased through the addition of ORCs. The addition of ORCs is one of the most promising in-situ techniques for cleaning up dissolved fuel components like benzene, toluene,

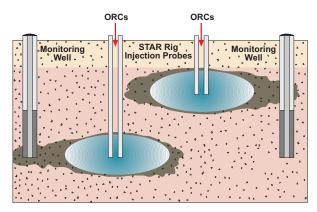


Figure 6-17. Biodegradation of Contaminants with Oxygen Releasing Compounds

ethylbenzene, and xylenes (BTEX). We tested ORCs on dissolved fuel in the groundwater at Site 17 in OU1.

We injected ORCs at Site 17 at a cost of only \$10,000, using the STAR rig to drive the probes. Following injection, groundwater samples were analyzed for BTEX. The BTEX concentrations in the test area decreased by approximately 500 parts per million (ppm) in the months following the ORC injection.

ORCs offer the following advantages:

- The in-situ method requires no long-term energy input;
- One injection is normally effective at maintaining elevated dissolved oxygen levels for up to six months; and
- The ORC slurry can also be combined with other important nutrients, such as nitrates and phosphates.

Magnesium oxide is the most common ORC; it is mixed into a water slurry and injected under pressure into the subsurface through probes.

IN-WELL VAPOR STRIPPING

In a cooperative effort between Edwards AFB, Battelle Pacific Northwest National Laboratory, and Stanford University, another new in-situ remedial technology, In-Well Vapor In-Well Vapor Stripping technology treats groundwater in-situ and avoids water disposal costs. Stripping, is being field tested at Site 19 in OU1. It has been developed in various configurations, but its basic characteristics are as follows:

- Air is injected through a tube inserted to the bottom of the inner well;
- A bubble column is created in which the air and groundwater are lifted through the well;
- Dissolved VOCs in the groundwater are transferred to the vapor phase in a stripping action created by the injected air;

on it.

Hosting tests of

innovative technolo-

gies helps us in two

ways. First, it's an

opportunity to get

minimal cost. And

out if a cleanup

second, we can find

method will work at

Edwards before we

spend a lot of money

contamination

cleaned up for

- The bubbles are released at the water surface in the inner well, and the VOCs are removed by a vacuum applied on the outer well casing; and
- The groundwater flows through slots in the outer well casing and back into the aquifer.

The system is a "closed loop" because extracted vapors are passed through a treatment system at the surface to remove VOCs and reinjected down the well to cause the air lift effect. The technology holds



Figure 6-18. In-Well Vapor Stripping Test

promise for addressing "hot spots" contaminated with VOCs, such as TCE. In-Well Vapor Stripping is limited to sites with sufficiently-thick saturated alluvium so that the well casing is long enough to allow stripping of the VOCs from the groundwater.

The six-month demonstration at Site 19 was so successful that testing was continued at another contaminated area within the site. We are also testing a modification of the technique called Bioenhanced In-Well Vapor Stripping.

AMMONIUM PERCHLORATE TREATMENT

Perchlorate contamination has been found in the soil and groundwater near the former JPL facilities at Edwards AFB; the releases resulted from ammonium perchlorate in solid rocket propellant. Edwards AFB is working with NASA to develop methods to test for and remediate perchlorate.

The relatively recent identification of perchlorate as a contaminant at many groundwater sites around the U.S. has prompted more attention to the problem; however, the health effects and the related regulatory action levels have yet to be completely determined. The provisional action level set by the State of California in 1997 was 18 ppb. The USEPA set a Drinking Water Equivalent Level of 31.5 ppb in 1999; that Equivalent Level is being considered in the development of a Health Advisory.

JPL Pasadena is conducting a pilot test of ion exchange treatment with Calgon Carbon Corporation using the Ion Separator (ISEP) process. The ISEP process uses a number of ion exchange beds (usually 30) that are mounted on a slowly rotating carousel.

The rotation of the carousel moves the beds slowly through the required sequence of adsorption, backwash, regeneration, and

lon exchange treatment of perchlorate is being evaluated.

rinse, which are conducted simultaneously as the carousel rotates. Fluids are distributed to each bed through an upper or lower portion allowing for either concurrent or counter-current flow.

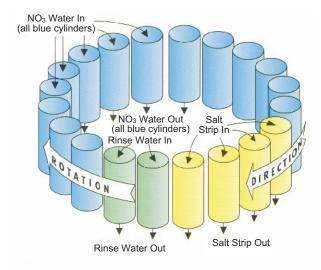


Figure 6-19. Calgon Ion Exchange Unit

The ISEP process is reported to operate at relatively lower costs than standard fixed-bed ion exchange systems. Previous pilot testing of the ISEP unit treated roughly 29,000 gallons of perchlorate-contaminated groundwater and performed 35 regenerations. The system appeared successful in reducing the perchlorate concentrations in the groundwater from 76 ppb to "non-detectable" (less than four ppb) levels. The system may be tested at Edwards AFB.

USE OF GRANULAR ACTIVATED CARBON

Of all the treatment technologies used to remove contaminants from vapors or groundwater, the use of Granular Activated Carbon (GAC) is probably one of the oldest and most reliable. GAC is proven to work for a wide range of contaminants in vapors and groundwater, is easy to use, is reliable, has few moving parts, and is cost effective above certain contaminant concentrations.

GAC has limited physical capacity and its regeneration involves dismantling the unit, refilling with fresh GAC, and transporting and treating the spent GAC, so its maintenance costs can be high. But

Economics of GAC use can be improved.

for low to moderate concentrations of organics, we've proven in our applications that GAC is still more economical than nearly all competing technologies. We decided to improve GAC's economics further:

- We use a central GAC treatment location:
- · We buy used GAC equipment; and
- We transfer GAC units between sites, matching GAC capacity to site needs.

As an alternative to GAC, we are testing vaporphase VOC treatment with biotrickling filters.

BIOFILTRATION

Edwards AFB is participating with the University of California-Riverside and the University of Southern

California in demonstrating vapor treatment via biotrickling filters, called "biofiltration." The process consists of:

 Packed towers that are flooded with water, 5 feet wide by 11 feet tall; Edwards AFB is partnering with state universities to demonstrate biofiltration.

- Biomass (colonies of bacteria and algae that eventually grow on the internal packing);
- Nutrients and pH control additives that are metered into the towers;

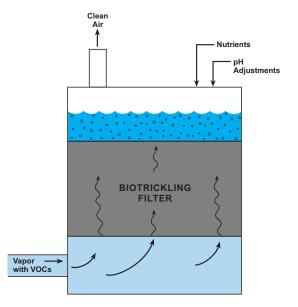


Figure 6-20. Biotrickling Filter

- Contaminated vapors that enter at the bottom of the tower and bubble upwards through the packed beds and biomass;
- Bacteria that consume the organic matter in the vapors, converting it to cell mass, carbon dioxide, and water; and
- Flow that is 200 cubic feet per minute.
 Here is what we've learned so far. The advantages of biofiltration over GAC use are that:
- Contaminants are destroyed, not simply adsorbed onto another medium; and
- GAC regeneration is eliminated.
 Biofiltration has these limitations:
- Limited capacity to handle high concentrations of contaminants:
- Not considered effective for treating chlorinated organics; and

Some byproduct handling may be necessary, including the disposal of waste excess biomass.

Biotrickling filters are being tested at Site 17

Biotrickling filters are being tested at Site 17 in OU1. The demonstration costs will be shared by Edwards AFB and the universities; we provide mainly O&M support.

USE OF INTERNAL COMBUSTION ENGINES

In cooperation with AFCEE, Edwards AFB evaluated the performance of a portable Internal Combustion (IC) Engine to treat petroleum hydrocarbon vapors at Site 24 in OU1. We successfully demonstrated the capacity of the IC Engine to efficiently extract and destroy VOCs.

The IC Engine system consists of a fully-enclosed, trailer-mounted automotive engine, which operates as follows:

- VOCs are removed through vapor extraction wells by the force of the engine intake vacuum;
- The extracted VOCs enter the engine in the combustion air stream;
- VOCs are destroyed as the fuel/air mixture ignites in the engine; and
- Post-combustion vapors discharged to the atmosphere are treated with a catalytic converter.

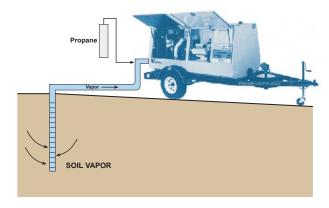


Figure 6-21. Internal Combustion Engine Unit

Following the successful six-month test, we kept the IC Engine running at the site and plan to use it at similar areas. We also purchased a more powerful six-cylinder IC Engine, now being used at Site 223 in OU2.

The test demonstrated that if the energy content of the extracted vapors is relatively high, an IC Engine

can operate with little or no extra fuel. As the VOC concentrations decrease, the extracted vapors are supplemented with propane.

IC Engine systems have the following advantages:

- They are small, portable, and can be mobilized and set up quickly;
- The test demonstrated capacity of an IC Engine to efficiently extract and destroy VOCs.
- They have a built-in capacity to provide the vacuum necessary to directly extract vapors from wells:
- They may not need any extra fuel for a period after start up; and
- The IC engine can operate over a wide range of contaminant concentrations.

OTHER NEW COST-AVOIDANCE TECHNIQUES

Three more cost-avoidance techniques are discussed here. Micropurging is a method of drastically reducing the amount of waste groundwater generated while

purging and sampling monitoring wells. Supervisory Control and Data Acquisition (SCADA) computerized systems provide us with a means of tracking the real-time status of any remedial systems in operation. We also discuss the advantages of having all equipment skid-mounted.

MICROPURGING GROUNDWATER WELLS

It's not often we get to install a new technology and see it **pay for itself in less than two years**. Here's what we mean:

When groundwater investigation or monitoring wells are conventionally sampled, the stagnant water in the well is bailed out or "purged." Three to five well volumes of purge water are generated per well which require treatment and disposal.

Micropurge
Technology reduces
the time and effort
to sample groundwater—and pays for
itself in less than
two years.

Several hundred gallons of waste groundwater are generated as IDW from every sampling round, several times a year. The handling, transport, treatment and disposal costs can be very large. Early in our program, we took two steps that avoid most of these costs:

- We converted to Micropurging sampling techniques; and
- We established regional IDW staging areas on base.

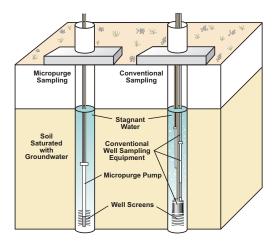


Figure 6-22. Micropurge and Conventional Sampling in Monitoring Wells

Micropurging involves installing dedicated lowflow pumps in each well that purge and sample

groundwater at a low-flow rate directly at the well screens, bypassing the stagnant water higher in the well. Bypassing the stagnant water means that several well volumes of water do not have to be purged from the well. Only a few gallons are removed.

Micropurge pumps will cut by nearly two-thirds the time and money required to take samples.

Having dedicated pumps at each well brings four other advantages:

- Easier, faster sampling;
- No need to decontaminate a conventional removable pump or bailer between wells;
- Pumps cost only \$1,000 per well; and
- Pumps eliminate large volumes of contaminated purge water requiring treatment and disposal.

Conventional sampling of 260 wells in OUs 1, 2, and 5/10, involving non-dedicated pumps and extensive purging, costs \$1,700 per well or \$442,000 annually. Sampling the same wells using dedicated micropurge pumps costs \$600 per well, for a savings of \$1,100 per well, or savings of \$286,000 annually.

To reduce the time and effort to transport across Edwards AFB the volume of purge water that we still generate, we established three "regional" IDW staging areas in this way:

- Staging areas at Main Base, South Base, and AFRL:
- Each staging area with one or two rented water storage tanks;
- If we fill just one tank a year, we save \$100,000 in laboratory costs.
- When each tank is full, a single, composite water sample is analyzed (rather than 100 samples collected from the 100 well purging events that are stored in the tank);
- The water is treated through GAC filters; and
- The water is discharged into evaporation ponds or into the sanitary sewer.

A fourth staging area is being constructed at North Base.

SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA)

One way to reduce the payout period of a remedial system is to minimize system downtime. Our SCADA system, using Intellution Software, remotely monitors the operation and status of remedial equipment.

SCADA automatically records the following operations data from the systems at preset time intervals:

- Pressure;
- Temperature;
- pH;
- Flow rate:
- Groundwater extraction rate; and
- Lower explosive level.

Using SCADA, we can view the current operations data, record historical performance data, and turn the systems off without leaving our office.



Figure 6-23. SCADA System

If SCADA saves us just two field days a month, over its 5-year life, for 15 LTO sites, we will save \$720,000.

The data are stored as a historical record of parameters versus time. SCADA also provides an important safety mechanism; with SCADA we can shut down remediation equipment from our office if an emergency were to occur.

SCADA's sensing and telemetry works over standard phone lines or over a cellular system. We have a dedicated computer terminal that displays real-time SCADA data continuously and historical data on request.

SKID-MOUNTED EQUIPMENT

None of the remedial systems at Edwards AFB are considered permanent, so it doesn't make sense to design and install them permanently at any site. Since we began our first removal action, all remediation equipment has been built on steel frames or skids, or is installed in trailers to give the equipment mobility. The remedial systems are either part of a Treatability Study or pilot-scale test, or will be used in IRAs for source removal and "hot spot" reduction, so it is important that the equipment be designed with portability in mind.

Equipment mobility and reusability are built-in, common sense approaches we use at Edwards AFB. When a Treatability Study is completed or the

remedial performance of the equipment at a particular site has declined, the equipment can be moved to other sites on base and reused. Large systems are built on more than one skid so that individual units (like a water treatment system) can be

All remediation equipment is skid-mounted and mobile.

moved and reused at another site without having to move the entire system.



Figure 6-24. Skid-mounted Equipment on Pad

LONG-TERM MONITORING (LTM) AS A REMEDIAL ALTERNATIVE

Long-Term Monitoring is a reasonable remedial alternative for sites where contamination is not moving and the risk of exposure is minimized and properly managed. There is no compelling technical justification for

implementing a costly remediation at a site posing little or no risk to human health or the environment. A more prudent approach is to implement a monitoring

LTM will be a key in our long-term closure steps.

program that checks that the contamination remains immobile and ensures that the risk remains properly managed and minimized.

We anticipate that LTM will be an integral part of the long-term closure steps at Edwards AFB. We collect data semiannually that demonstrate that most of the contamination lies within an aquifer that is moving very slowly. Models and predictions from models are demonstrating that the contamination does not now and is unlikely to ever threaten any nearby receptors.

Extracting contamination from the aquifer in granitic bedrock that underlies most of the Base is not practical. It is much more cost effective to use a program of institutional controls and LTM. If it can be proven that the contamination poses no risk to human health or the environment now or in the foreseeable future, it should not be necessary to extract the contamination, at great cost, from the bedrock.

INSTITUTIONAL CONTROLS (ICS) AS A RISK REDUCTION METHOD

Institutional Controls are a cornerstone to the management of risk. When a system is in Long-Term Operations, we explain that there are risks associated with the site and that it also requires Institutional Controls.

ICs at a site indicate that contamination is still present but that the risk to human health and the environment has been minimized and is manageable to acceptable levels. The controls are the means by which contact with the residual contamination is prevented.

ICs are used in conjunction with other cleanup methods at such sites. ICs are used to *first* deny access and break the exposure pathway. They are used *later* to provide informed access to areas, though only to areas where concentrations are below those immediately dangerous to life and health.

It is critical that the controls be constant and enforceable. We will use various controls to advise people against digging or pumping groundwater at our IC sites: physical barriers like fences, gates, and guards; administrative controls like prohibitions and the wording of certain Operating Instructions and Standard Operating Procedures; and notices, warnings, signs, and announcements.

IC requirements will remain as part of the site history, the history of the property, the Base Standard Operating Procedures, the Comprehensive Plans, and in planning and zoning decisions and records. Institutional Controls will be documented in our files and in GIS site maps.

HAZARD AND FAULT ANALYSES AT LTO SITES

Here is another tool we use to reduce risks at IRP sites. For each site in Long-Term Operations, we prepare a Hazard and Fault Analysis that determines the potential hazards and incidents associated with LTO equipment and operations.

LTO sites are actually chemical/physical/biological process units with hazardous materials present, hazardous and flammable materials being pumped into tanks and transported in piping, and possibly diesel fuel in storage. We believe these chemical process units located outside where access has historically been controlled only by a fence ought to receive the same attention with regard to hazardous materials incidents as any other small chemical plant. There are risks of injury, accident, fire, spills, and other releases at our LTO sites. EMR decided to perform hazard and safety risk analyses and place controls on the risk elements we find. Our Hazard Analysis Report also satisfies our regulatory agencies' desire to see planning documents for these sites that recognize and mitigate against risk of spills and releases.

The Hazard Analyses are performed using a combination of techniques from the disciplines of

safety engineering, mechanical engineering, environmental compliance, process engineering, spill and release prevention, and fire prevention. We also use techniques and requirements from "HazOps" (hazards and operability) studies and SARA Title III reporting. We combine the techniques in a flowchart and decision tree that uses inputs of all the unit descriptions, hazardous materials, and processes on site and tracks those through to determine hazards and failure modes.

Hazard and Fault Analyses at LTO sites include:

- A description of every possible hazard, failure mode, equipment breakdown mode, incident scenario, and spill, release, or fire scenario;
- · Prevention procedures; and
- Safe response procedures that protect human health and the environment.

We would like to note an important point. The operations and maintenance (O&M) of these LTO sites will pass through many hands in their 20-year life. EMR personnel and contractors operate the sites now. After a few years, duties may pass on to other organizations or contractors. We're confident each of these organizations and contractors has ample notification, training, safety, and other requirements for all personnel and contractors. However, EMR felt

it was important to do our part to document the hazards, breakdown modes, and response procedures now. We are beginning to answer the follow-on operators' concerns and help train them.

Through the results of the Hazard and Fault Analyses, we are able to:

- · Prevent spills;
- Inform operators so they can protect themselves and the environment;
- Determine the training required for site personnel;
- Publish our findings in newspapers and use them in briefings;
- Communicate safe practices to our customers;
- Help the hospital develop lists of symptoms and treatments for chemical exposure;
- Write Standard Operating Procedures;
- Prevent equipment problems and subsequent chemical releases; and
- Decrease equipment downtime.

The results, precautions, and restrictions that arise from our Hazards and Fault Analyses will **become part of the Engineering Controls around these IRP sites** and will stay with the sites as long as the equipment is operating.

CHAPTER 7

COMMUNITY INVOLVEMENT INITIATIVES

The statement that drives EMR's community involvement program is simple: "We inform everyone early and often. We are open and honest in our communication. Everyone who has opinions and suggestions is welcomed at the table, invited to share his or her ideas, and is encouraged to stay involved. We will then use everyone's suggestions wherever they are feasible and share what we have learned." With that commitment, what are the best possible ways to keep our citizens and other groups well informed and keep them involved? Our methods for community involvement fall into three areas:

- Our approach to record keeping (p. 7-1);
- The establishment of our RAB and the mechanisms to support it (p. 7-3); and
- Our reaching out to our communities with materials that make contact at many different levels (p. 7-4 through 7-9).

AN EARLY PLAN FOR FILE ORGANIZATION, INFORMATION REPOSITORIES, AND THE ADMINISTRATIVE RECORD (AR)

The Edwards AFB IRP program files occupy hundreds of cubic feet of file space. Years ago, EMR looked far ahead to the size and complexity of the program files, their need for quick access to files, and the crucial need to eventually transform a subset of the program files into the AR. EMR also uses its files and many other materials to help keep the public informed about and involved in the IRP. How could EMR accomplish all these goals? We accomplished them through smart, early planning and implementation. Here are some details about our IRP file and library organization:

- We established our library and its resources early in the program.
- The organization and shelving system were also developed early in a written Operating Instruction (OI).
- Our full-time librarian barcodes paper documents and shelves them according to the written OI.

 Documents from the last several years are available electronically.
 A few older documents have been scanned and are now available as images.

We inform everyone about our program early and often.

Making these decisions early on about our file and document library and establishing the resources to accurately maintain the files has saved us the large effort it would have taken had we waited to organize our files. We also check the quality and accuracy of our filing system. We have audited our library by having "strangers" request documents. The requests were filled quickly and with very few errors.

We made early decisions about the IRP document library and established the required resources to maintain the files.

How do we solve the problem of using this large, imposing volume of information to inform and involve our communities? Our four smaller Information Repositories (IRs), both on and off base, handle that job for us. The IRs contain several

kinds of useful materials and information to help interest the public and answer their questions:

- Technical documents that are available for public comment:
- Fact sheets and synopses prepared by EMR to acquaint the RPMs and others with EMR's challenges and the technologies EMR is implementing;
- · Maps and diagrams; and
- · Copies of our monthly "Report to Stakeholders."

We have one IR on base and three off base in Boron, Lancaster, and Rosamond. We make our Repositories convenient, easy to use, and we expend the effort to keep them up to date. Our credibility and the IRP's progress have both benefited. In Boron, we found the library was not open every day. We searched for and found a space that is open more days per week—the local museum. It is evident that the people of Boron are pleased with that decision.

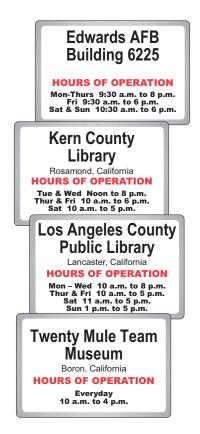


Figure 7-1. Hours of Operation for our Information Repositories

We are careful to remove documents from the Information Repositories when comment periods expire. We are careful to remove documents from the Repositories when comment periods expire. This effort will keep people from becoming frustrated when their comments cannot be responded to because the public comment period has closed and the document has been finalized.

What else has EMR accomplished that yields a high return? Only documents used to make a cleanup *decision* will become

part of the AR in 2004. At that time, the AR must be formed from our program files. We have already made that transition easier and less time consuming; our OIs dictate which documents

Only documents used to make a cleanup decision will become part of the AR.

will be part of the AR and which will not. Knowing and using that part of CERCLA will minimize the size of our AR and thereby realize a huge difference in the taxpayer dollars needed to store and maintain it.

FORMATION AND TRAINING OF OUR RAB

To hear our communities' concerns and involve them in the solutions, we formed a Technical Review Committee (TRC) in 1990 as soon as Edwards AFB was listed on the NPL. The TRC later became our RAB. We keep the RAB well informed and, in turn, RAB members carry information and news of our progress into our communities, speak with many more of their neighbors than we could, listen to their

neighbors' concerns, and communicate these concerns to EMR and the RPMs.

Our RAB members come from different backgrounds.

In 1990, when we were forming the TRC, we asked for volunteers from

our on-base residents and from all our surrounding communities. Four volunteers joined the TRC. We soon added three more members and, with guidance from the Keystone Report, asked the seven members to write their own charter and member selection criteria for becoming our RAB. EMR was not involved in the development of the charter or member selection criteria.

Our original members decided the RAB should also have representatives from the workplace, so employees from NASA-Dryden, the AFRL (then called Phillips Laboratory), Edwards Main Base, Edwards South Base, and Edwards North Base were added as members. The members come from different backgrounds; we have teachers, retired professionals, Edwards AFB employees, and members who have resided in our valley for decades.

We are committed to always being open and honest with our RAB members. They visit us in the EMR offices and accompany us on site tours with the RPMs. Their interaction with the IRP has grown steadily. For example, the RAB members wanted more written information to refer to and share with their neighbors, so they developed with us our monthly Report To Stakeholders. The Report To Stakeholders



Figure 7-2. The Report to Stakeholders

states our progress in site investigation and risk reduction, and contains informative articles on:

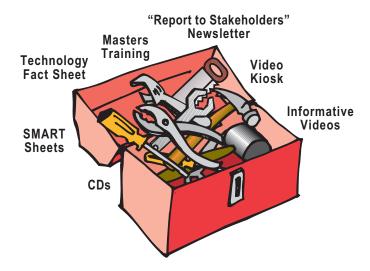
- Established and new technologies;
- · Regulations;
- Investigation techniques;
- · Laboratory methods; and
- · Site histories.

We now distribute over 5,000 copies a month to onand off-base homes, to on-base activities and workplaces, and in the Base newspaper *Desert Wings*. The Report to Stakeholders is also available on the World Wide Web. The RAB members have expressed their appreciation for and their interest in the breadth and depth of the information the Report to Stakeholders provides and also how well it communicates the IRP to their neighbors.

Our efforts have been rewarded; some RAB members have continued volunteering for several years, and our communities support the IRP. We rely heavily on our RAB members' involvement and continue to develop more tools for their "tool kit."

THE RAB's "TOOL KIT"

We continuously seek to answer the question "What is the minimum 'tool kit' our RAB members need to stay involved and effective? What else can EMR provide, in what format, and in what medium? What training can we provide that is a wise use of our resources?"



We have already provided extensive training to the RAB; we have hosted two off-site weekend training sessions. Both sessions were very well attended. Ten training modules were presented, covering a range of technical subjects from hydrogeology and cleanup technologies to regulatory training on RCRA and CERCLA. In 1999, we hosted a RAB Masters Program where we built on the earlier subjects and



Figure 7-3. RAB Off-Site Training

We hosted two off-site weekend training sessions for the RAB in 1997 and 1999.

added decision-making exercises as well. In these exercises, we gave the RAB members the same kind of site information and contamination data that we usually gather about a site, and they made decisions about project

priority, timelines, and the technologies to use in risk reduction.

EMR has also developed and provided to our RAB, our stakeholders, RPMs, and our communities:

- · Technology fact sheets.
- "Smart Sheets" that give helpful information on how to understand health risk, regulations, and concepts like "parts per million" and "parts per billion."
- Instructional materials that are now easily and inexpensively provided on compact discs.
- Our Lobby Kiosk, which displays an interactive video about the IRP and is particularly valuable for involving our on-base population. Employees and residents can also direct their neighbors and coworkers to the Kiosk.



Figure 7-4. Environmental Management's Video Kiosk

We continue to look for more ideas for tools to add to our RAB community involvement "tool kit." These training materials and workshops have yielded many benefits to the IRP:

- At the off-site training, RAB members, RPMs, and EMR PMs could get to know each other on a personal level, be frank and open about their concerns, and are continuing to be frank with each other today;
- When our communities and RAB members are well informed, their suggestions are more focused;
- Interactions with our communities would not be as pleasant or helpful if our citizens operated on misinformation or rumors; and
- Our PMs benefit from preparing the training materials and fact sheets:
 - Preparing the materials deepens the PMs' technical understanding, and
 - For the training sessions, PMs explain regulations and technologies in clear, simple terms—and they find that their own understanding is enhanced when they must express the ideas simply.

Finally, the training and other materials—which are relatively easy for us to develop—are a wise investment of our resources. The RAB members are volunteers and they are the front line in our community involvement efforts. Their time and energy are invaluable to our program. If they have poor information and insufficient tools, they can sway public opinion in the wrong direction. When the RAB members have the right tools, they are effective spokespersons for the team.

When the RAB members have the right tools, they are effective spokespersons for the team.

NINE MORE WAYS WE'VE REACHED OUT TO INFORM AND INVOLVE OUR RAB AND OUR COMMUNITIES

PROFESSIONAL VIDEOS

We listened when the RAB said it wanted tools that would give a big picture view of the Base, its history, and its challenges, and would do so in a brief and very attractive format. Professionally-produced videos were the answer.

RAB members are asked to speak to civic organizations and needed a way to explain technical

jargon and technologies quickly, accurately, consistently, and simply. We searched for a way to satisfy the RAB's request, knowing that the RAB was helping us build community support.

The Environmental Management Directorate was using professionally-produced videos to explain the functions of EM. Videos are not a good format for explaining site details, but they are very good for explaining large-scale ideas and efforts. Professional videos show a real respect for the

audience because they
are pleasant to
watch and
learn
from.

The Edwards AFB
Geographic
Information
System

The Edwards AFB
Installation
Restoration
Program

Figure 7-5. Professional Videos

To date we have produced four professional videos: "The Edwards AFB Installation Restoration Program," "The Edwards Geographic Information System," "South Base: Yesterday and Tomorrow," and "The Cleanup Requirement Information System." To increase the return on our investment in our videos, we have adopted a completely new electronic format that we believe is new in the Air Force: a video Kiosk for our lobby. It contains a user-interactive, touch-screen video that offers instruction and news about all aspects of environmental management at Edwards AFB, and offers a way to easily and inexpensively update our earlier IRP videos.

To promote the use of our recently-developed decision-support software called CRIS (Cleanup Requirement Information System), we have taken a new direction: a multi-media presentation. We have packaged together on a compact disc the software, a

tutorial program, an electronic user's manual, and a video that explains the development of and the benefits derived from the CRIS software. The software and the video can be viewed from the compact disc without the need for a television and

Professionallyproduced videos are not expensive and offer an excellent return on our investment.

Because video is an excellent format for explaining the big picture, we are

planning a video to explain our approach to finding and managing CWM sites on base.

Professionally-produced videos are not expensive, and when amortized over the number of times they can be used to give —in a few minutes—a simple and accurate explanation of a large program and a large effort, they offer an excellent return on our investment.

OUR MONTHLY STATUS REPORT

In accordance with our FFA, we began publishing a Monthly Status Report (MSR) that contained lots of data, but was long, unwieldy, and often went unread. We and our RPMs and RAB members wanted to

develop an MSR in a new format that would be easy to read and would help everyone come fully up to speed on technical progress between meetings, even when several months had passed. To do this, we took a closer look at the status reports that contractors were already required to submit to the contracting officer. From

Our short, easy-toread Monthly Status Report requires only slight changes to the contractors' existing status reports.

that material we developed an MSR that requires only slight reformatting of the status reports the contractors already provide, yet covers each OU completely and



Installation Restoration Program

Status Report

September 1999

Figure 7-6. Status Report, September 1999

concisely. Now the RAB and RPM meetings proceed directly to new information and new business instead of pausing for an hour of updates. We use everyone's time more wisely and make more progress at each meeting.

Now we publish our MSR on our web site so more people can view it. The combination of our MSRs and Reports to Stakeholders satisfies the History Office's requirement to prepare an annual history on the IRP. There is almost no additional expense because we keep our eye on continuous improvement and increasing the return on our investment.

PLACING DOCUMENTS ON THE INTERNET

The Internet is logically our next avenue for reaching out to our communities to inform them, involve them, and answer their concerns. The monthly Report to Stakeholders and the MSR are on the Internet now.

We are also mindful of those who don't have Internet access, so we will always produce hard copies and mail them out.

We have already had dozens of requests for copies of our Report to Stakeholders from other Centers, Air Force personnel, and from other services after seeing We post our documents and Lessons Learned on the Internet at http://www.edwards.af.mil/penvmng/

our Report to Stakeholders on the Internet. Getting requests from other services tells us we are doing something right—and publicizing it correctly.

Closer to home we have also had proof that our Internet outreach is succeeding. A local cleanup contractor sought out the EMR booth at the Antelope Valley Fair after visiting our Web site.

IRP SITE TOURS

For our RPMs, our RAB, and our base visitors, we conduct tours of IRP sites where we teach visitors about:

- Our history and the nature of the contamination here;
- Our hydrogeology, groundwater movement, and the risks to human health and the environment;
- Our investigation techniques and cleanup technologies and the challenges presented by both;
 and
- · Our progress in reducing risk.

We call the tours "Toxic Tours" and we have hosted many groups. Several visitors have told us how much they benefited from seeing the IRP sites and our challenges and progress.



Figure 7-7. IRP Site Tour

INFORMATION PACKETS FOR "NFI" TOURS

Because we are determined to close sites as quickly as possible, we have developed new ways to save time. "NFI Tours" are one of our innovations.

Since 1992, whenever we have several sites that are candidates for a finding of NFI, we plan an "NFI Tour." We prepare an Information Packet for the RPMs that is a bound handout for each site, containing all the sample locations, sample results, and our justification for the NFI finding. We begin the

Sites are often closed after NFI Tours. tour with a slide show presented by the PM and the contractor that refamiliarizes the RPMs with each site, and then spend ample time answering each RPM's questions. Sites are often closed after only these presentations, but RPMs usually want to see any

site where residual contamination will remain in the ground.

A scribe is present all day, recording all meeting minutes and the agreements made. The minutes become part of the Administrative Record. We have original, unsigned NFI letters

with us on the tour. If the RPMs agree with the NFIs, the NFI letters are signed on the hood of the car.

NFI letters are signed right at the site!

We pioneered another innovation to save RPMs' time

and make comment cycles shorter and more efficient. Before meetings, the RPMs receive Site Summaries for the sites that will be discussed. They enter their comments and questions as margin notes and bring them to the meetings. At the meetings, the RPMs raise their questions, voice their concerns, and get answers without having to write their comments into formal correspondence. And we avoid the long comment-review-revision cycles: The answers to their questions are recorded directly into the Meeting Minutes, saving lots of steps and everyone's time. We estimate that if

Reduced comment cycle time saves \$180,000.

we save only one month per year of document revisions by one PM and one contractor staff member for the years 1996 through 2004, we will save \$180,000.

SAMPLING NEIGHBORS' WATER WELLS

In many cases, our neighbors in surrounding towns get their drinking water from their private water wells. They had read of the perchlorate "scare" in their newspapers, made the connection with rocket fuel research and rocket fuel storage at tenant locations on Edwards AFB, and wanted to know whether their wells were contaminated.

We already knew from our own groundwater sampling and hydrology models that off-base wells



Figure 7-8. Sampling Water Wells

were not contaminated. To verify our results, we arranged for a California State agency to sample our neighbors' wells and, in a

matter of weeks, proved that the wells were not contaminated with perchlorate.

"PUBLIC HEALTH ASSESSMENT INFORMATION SUPPORT DOCUMENT" PREPARED FOR ATSDR'S INSPECTION

All facilities on the NPL are required to undergo a Public Health Assessment (PHA) by a team from the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR conducted its initial scoping visit at Edwards AFB in 1991. Because of the progress made by the IRP since then, we decided to prepare a basewide summary document for the ATSDR team and send it to them before their next visit as a costefficient way to bring them up to date on our progress since 1991.

The Occupational and Environmental Health Directorate of the Air Force Human Systems Center (HSC) works with ATSDR at military bases. EMR met with HSC personnel many times between 1991 and 1998. We kept the HSC representatives well informed about our contaminated sites and our cleanup efforts. HSC reviewed and commented on our risk reduction efforts and our community involvement and outreach programs. We, in turn, were well

prepared when we developed the Information Support Document for ATSDR for their PHA visit in 1998.

Our document presented a complete, but very concise, installation history and a history and description of each OU. For each OU, we described the source, nature, and extent of contamination, the progress in risk reduction efforts thus far, and an evaluation of the risks to human health that exist in that OU. We also described our community education and involvement efforts created to inform the community about human health risks from each OU.

The initial results from the ATSDR Assessment are that there are no significant exposure pathways from our cleanup sites to the public.

FULL-TIME COMMUNITY RELATIONS PROFESSIONAL FOR EMR

Every Restoration Program knows how important it is to convert technical facts and technical jargon into community-focused, helpful information. A Community Relations staff member needs a thorough and growing knowledge of investigation methods, cleanup technologies, RCRA and CERCLA statutes and regulations, and an ability to understand and communicate the actual risk to human health and the measures constantly taken to reduce that risk. Our

Restoration
Programs benefit
greatly from having
a member of the
Public Affairs
staff dedicated to
the IRP.

program also requires special RAB and community involvement skills. We decided early in the program that we would benefit greatly from having a member of the Public Affairs staff dedicated to the IRP; we arranged to have a full-time Community Relations professional

matrixed to EMR. Edwards AFB's Public Affairs Office retains all "release authority" for official communiqués and press releases from EMR, but we have benefited immensely by having full-time Public Affairs support on hand to convert technical language into community-focused, helpful information, and answer our citizens' questions and concerns.

IRP IS TRANSPARENT TO THE MISSION, YET VISIBLE

One of our customers and one of the audiences for our Community Relations efforts is the Flight Test Center and the test mission itself. We go to great lengths to cooperate with and not interfere with the test mission.

In return, the Flight Test Center cooperates with the IRP

We brief activities and ask permission to drill holes near their buildings. We educate mission personnel on why we need to clean up their environment; in return, mission personnel volunteer helpful information. If there We go to great lengths to cooperate with and not interfere with the test mission.

is a schedule conflict between Test Center activities and the IRP, we now find that Test personnel will suggest the best time for IRP activities to occur that will least affect the mission.

Our outreach to Test Center activities has been rewarded; activities feel some ownership over the cleanup and demonstrate that with their cooperation. Our efforts and progress are visible to people; the IRP is transparent to the mission.

This chapter has given just the highlights of the 12 initiatives and innovations that have brought success to our Community Relations program. If, through our various RAB training and involvement activities, we have saved only 100 hours a year of debate and consensus building with the RAB members—just 33 hours each by three people—then by 2004, we will have saved \$53,460. Likewise, if our other Community Relations efforts have saved just 100 hours a year of responding to misinformation, we have saved another \$53,460.

Our total savings generated from these initiatives and innovations are estimated, conservatively, at \$287,000. Considering how public controversy can derail a program for months, we believe our real savings are probably many times that figure.

CHAPTER 8 ADVANTAGES TO THE LOCAL ECONOMY

The Edwards AFB IRP has benefited the local community and the region. Since the formal inception of the IRP in 1990, it has grown from a budget of \$5 million dollars a year to approximately \$25 million

The Edwards AFB IRP has infused over \$100 million into the Antelope Valley economy.

dollars annually, and has infused over \$100 million into nearby communities and the Antelope Valley economy.

The work effort has increased from the assistance of one contractor to include

over 150 contractors and suppliers. With the expansion of the program, the impact on the Antelope Valley has been significant. Local suppliers, such as Home Base, Little Ice, and Valley Well Development,

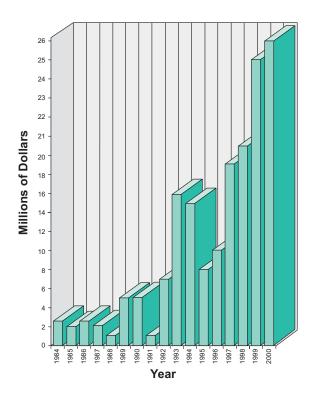


Figure 8-1. Edwards Air Force Base IRP Funding by Fiscal Year 1984-2000

have been used whenever possible to provide parts and services. In addition, due to the remote location of Edwards AFB, support personnel have generally rented and resided in the local area or have stayed at local hotels such as the Antelope Valley Inn and the Desert Inn.

The figure describes the IRP's annual expenditures and indicates the effect of the Edwards AFB IRP on the local area and the region.

A partial list of the consultants and suppliers that we have worked with includes:

- 1. Aman Underground Storage Tank removal
- 2. A & R Drilling Drilling, development, and purging activities
- 3. A.J. Oster West Inc. Lab grade aluminum foil
- Access Drilling Drilling, development, and purging activities
- 5. ACO Sanitation Septic tank services
- 6. Air Kinetics Inc. Emission testing
- Air Liquide Calibration and treatment system gases
- 8. Air Quality Engineering Inc. Emission testing
- Antelope Valley Inn RAB training, TDY accommodations
- 10. Apex Drilling Drilling development, and purging activities
- 11. APPL Soil and water samples
- 12. Aquatic Testing Services Fish toxicity testing
- 13. Associated Concrete Products Well vaults
- 14. Baker Tank Water storage tank rentals
- BC2 Environmental Corp Subcontractor on monitoring well installation, development, purging, and sampling
- Beylik Drilling Drilling, development, and purging activities
- 17. Brooks Jensen Precast Well vaults
- 18. Brown Electric Site electrical work
- CALOLYMPIC Safety Health and Safety supplies
- 20. Carus Chemical Polyphosfate chemical
- 21. Cascade Subcontractor on monitoring well installation, development, purging, and sampling
- 22. CCL Engineering Borehole, well, and

- treatment facility surveying
- 23. CED Inc. Electrical supplies
- 24. Clean Environment Subcontractor on dedicated purge, sample, extraction, and low-flow sampling pumps and instruments
- Control Instrument Corp. Treatment system instruments and controls
- 26. Costco Supplies
- 27. CSC Engineering & technical support services
- 28. D. Appleton IDEF modeling of IRP processes
- DELL Computer purchases and warranted support
- 30. Desert Inn TDY accommodations (HAZWRAP), conferences, etc
- 31. Devonshire Inn Field crew accommodations
- 32. Diversified Well Products Well pipe/drilling supplies
- 33. Dwyer Instruments Treatment system instruments and controls
- 34. Earth Tech (Long Beach and Colton) Installation Restoration Program investigation and remediation services
- 35. Ecology Control Industries Water transport/vacuum truck services
- 36. EMAX Soil and water samples
- 37. Engineering Science Installation Restoration Program investigation and remediation services
- 38. Enterprise Rental Car Field vehicles
- 39. Envirodredge Installation Restoration Program investigation and remediation services
- 40. Environmental Support Tech. Soil gas surveys
- 41. Essex House TDY accommodations, conferences, etc
- 42. Fast Trip Dry ice
- 43. Fugro Subcontractor on Cone Penetrometer Testing/Rapid Optical Screening Tool
- 44. GE Capitol Trailer rental
- 45. GE Supply Treatment system instruments and controls
- 46. Geofon/RCI UST removal
- 47. George T. Hall Co. Treatment system instruments and controls

- 48. GM Safety Supply Safety and staking supplies
- 49. Gold Strike Motel Field crew accommodations
- 50. Golden Gate Fence
- 51. Great Plains Industries
- 52. GRW Engineers Initial loading of Geographic Information System data and collection and loading of photogrammetric data
- 53. GV Adams Water transport/vacuum truck services
- 54. Hanson Well-Do-Service Drilling, development, and purging activities
- Harrington Plastics Treatment system piping suppliers
- 56. HAZCO Field testing instruments
- 57. Hertz Heavy equipment/staging area rentals
- 58. Hewlett Packard Computer and accessory purchases and support
- 59. Home Base Hardware (construction and staging area supplies)
- 60. Home Depot Hardware (construction and staging area supplies)
- 61. IBM Computer and accessory purchases
- 62. IKON photocopier/facsimile machine services
- 63. Industrial Engineering and Equipment Air compressors
- 64. Industrial Waste Utilization OWS cleaning/abandonment
- 65. Inn of Lancaster TDY accommodations, conferences, etc
- 66. Intergraph Geographic Information System database optimization and support
- 67. IT Corp. Mobile Free Product Recovery equipment
- 68. Jacobs Engineering Installation Restoration Program investigation and remediation services
- Johnson Construction Subcontractor on remediation system construction (Site 11 SVE/AS system construction)
- 70. Karls Hardware Construction and staging area supplies
- 71. Kerco Insulation Treatment system piping insulation
- 72. Kern Environmental Services Subcontractor on

- remediation system construction (OWS system construction/UST removal)
- 73. KERR Safety Training Inc. HAZWOPER refresher training
- King Buck Technology Subcontractor on granular activated carbon system/Treatment system skids and components
- 75. K-Mart Trailer supplies
- 76. LAS Labs
- 77. Lee and Ro
- 78. Little Ice Dry ice
- 79. Lockheed Martin Marietta/HAZWRAP
- 80. Maness Environmental Subcontractor on remediation system construction (OWS Cleaning/Abandonment)
- 81. McCoys Associates RCRA seminars
- 82. Michael's Drum identification paint pens, office supplies
- 83. MJK Construction Subcontractor on dig and hauls OWS Cleaning/abandonment/UST removal
- 84. Morrison Knutsen
- 85. Motel 6 Field crew accommodations
- 86. MP Environmental Services OWS system construction/UST removal
- 87. National Instruments Treatment system instruments and controls
- 88. Norris Engle Trucking and Equipment Heavy equipment/staging area rentals
- 89. North East Environmental Products –
 Subcontractor on low profile air stripper and skid
 (treatment system skids and components)
- 90. Northridge Rentals Heavy equipment/staging area rentals
- 91. Northway Electrical contractor
- 92. Northwestern Carbon Carbon change outs/vessels
- 93. Oak Ridge National Labs Remote sensing of CWM sites
- 94. Office Depot Office supplies
- 95. On-Site Surveying Borehole, well, and treatment facility surveying
- 96. Osterbauer Compressors

- 97. Pacific Environmental Services Inc. Emission testing
- 98. Payless Trailer supplies
- 99. PONTON Industries Inc. Treatment system instruments and controls
- 100. Pro Flame Inc. Calibration and treatment system gases
- 101. Pure Effect Carbon change outs/vessels
- 102. QED Environmental QED Micro Purge pumps and instruments
- 103. Quadrel Services Inc. Passive soil gas surveys
- 104. Quanterra Environmental Soil and water samples, vapor samples (EPA certified lab)
- 105. R&S Consultants HAZWOPER refresher
- 106. Radian Installation Restoration Program investigation and remediation services
- 107. Rain for Rent Water storage tank rental
- 108. Resolution Resources Inc. Geophysical utility locate
- 109. Rio Bravo Resort Team building
- 110. Rio Mirada IRP Off-site
- 111. Oxford Inn TDY accommodations
- 112. RM Controls Inc. Treatment system instruments and controls
- 113. Rosco Moss Well pipe/drilling supplies
- 114. Rosedale Products of Ca. Treatment system filters
- 115. RSI Subcontractor on IC engine system
- 116. RSL Data reduction of Remote Sensing data
- 117. RUST E&I– Installation Restoration Program investigation and remediation (Now ET E&I)
- 118. Santa Fe Industrial Plastics Treatment system piping suppliers
- 119. Scott Specialty Gases Calibration and treatment system gases
- 120. Sea/Land Environmental OWS system construction/Treatment System/UST removal
- 121. Shipley's Training courses
- 122. Sinclair Well Products Well pipe/drilling supplies
- 123. Site Surveying Borehole, well, and treatment facility surveying

- 124. Smith Thompson Pumping Main base steam cleaner maintenance, OWS cleaning/ abandonment, and water transport/vacuum truck services
- 125. Soils Engineering Soil and concrete testing services
- 126. Spectrum Geophysics Geophysical utility locate
- 127. Staples Office supplies
- 128. Strata Physics Geophysical utility locate
- 129. Suburban Propane Calibration and treatment system gases
- 130. Super 8 Field crew accommodations
- 131. Sverdrup AFRL, (Test Stand 1-A)
- 132. Target Trailer supplies
- 133. Target Environmental Services Soil gas surveys
- 134. TEAM ATSDR preparation
- 135. TEG Inc. Subcontractor on soil gas surveys
- 136. Terra Physics Geophysical utility locate
- 137. Tetra Tech Installation Restoration Program investigation and remediation services
- ThermTech Subcontractor on thermal/catalytic oxidizer
- 139. Toneman Construction OWS system construction

- 140. Tracer Research Soil gas surveys
- 141. TYBRIN SETA contractor, support
- 142. Tyree Corporation Site 17 SVE/AS system construction
- 143. U.S. Filter/Westates Carbon change outs/vessels
- 144. UC Davis
- 145. US Rentals Backhoe and other heavy equipment/staging area rentals
- 146. Vallen Safety Supply Health and Safety supplies
- Valley Well Drilling Subcontractor on monitoring well installation, development, purging, and sampling
- 148. Vara International Treatment system skids and components
- 149. W. L. Gore & Assoc. Soil gas surveys
- Waste Management Trash and Roll Off Bin Service
- 151. Water Development Corp. Drilling, development, and purging activities
- 152. Wayne Perry Treatment system construction
- 153. Williams Cleaning Research Laboratory Decon Pad Maintenance
- 154. Zelco Laboratories

INDEX

| 2-D and 3-D Seismic Profiles4-4 | Chemical and Biological Warfare Sites, |
|--|--|
| Action Level2-2, 2-3, 2-4, 2-5 | Approach to Managing6-5 |
| Action Memoranda2-3 | Chemical Tracers4-9 |
| Active Soil Gas Surveys4-6 | Chemical Warfare Materiel (CWM)6-5 |
| Addressing Risk3-13 | Cleanup Requirement Information |
| Administrative Record, Early Plan3-6, 7-1 | System (CRIS)3-12 |
| Aerial Photos, Historical4-3 | Closure, Landfill6-3 |
| Aerial Survey4-5 | Cometabolic Biodegradation of TCE6-13 |
| AFRIMS Integrated Supplemental Database5-3 | Community Relations Professional7-8 |
| Air Sparging6-12 | Concentrations, Background Metals3-10, 5-4 |
| Analyses, Soil Gas4-6 | Cone Penetrometer Testing (CPT)4-7 |
| Analytical Lab, Base Environmental4-11 | CPT and CPT/ROST4-7 |
| Antelope Valley, Economic Impact to8-1 | CRIS (Cleanup Requirement |
| ARARs Database3-12 | Information System) Software3-12 |
| Archival Research2-2, 4-3 | Cultural and Historical Surveys3-5 |
| Areas of Concern1-1, 2-2, 3-1 | |
| AS/SVE6-12 | Database, AFRIMS Supplemental5-3 |
| ATSDR Document7-7 | Data Handling5-1 |
| | Data Quality Objectives (DQOs)1-4, 4-2 |
| Background Metals Documents3-10, 5-5, 6-4 | Dioxin Formation4-11 |
| Backfill3-13 | Document Management5-5 |
| Base Environmental Analytical | Downhole Video Assessments4-9 |
| Laboratory (BEAL)4-11 | Drill Cuttings3-13, 6-8 |
| Base Cleanup Strategy2-1 | Dual Extraction2-3, 6-10 |
| Base-wide Initiatives3-1, 6-4 | |
| Base-wide ROD, HRA, ERA2-5, 3-15 | EE/CAs1-5, 3-7, 3-15, 6-3 |
| Beryllium Contamination, Burial of6-9 | Environmental Restoration Division, |
| Biofiltration6-16 | Goals of1-2, 2-1 |
| Bioslurping2-3, 6-11 | EMR Business Plan1-3 |
| Biotrickling Filters6-16 | ERA, Single Base-wide3-15 |
| Bioventing2-3, 6-10 | ESI/RFA2-2, 3-1 |
| Boreholes4-8 | Excavation6-7 |
| | Expanded Source Investigation |
| California Department of Toxic | (ESI)2-2, 3-1 |
| Substances Control1-1 | Experimental Techniques3-8, 6-2 |
| California Regional Water Quality | |
| Control Board1-1 | Fact Sheets7-1, 7-4 |
| Carbon-14 Dating of Groundwater4-9 | Federal Facility Agreement (FFA)1-4 |
| CERCLA, Definition of1-1 | Fences6-9, 6-20 |
| CERCLA, Scaling Up3-2 | Formerly Used Defense Sites (FUDS)3-9 |
| CERCLA – RCRA Integration3-1 | Framework, Problem-solving1-3, 1-6 |
| CERCLA, Using to Clean Up RCRA | |
| OB/OD Sites3-11 | Geographic Information System (GIS)5-1 |
| CERCLA, Using to Reduce Risk6-2 | Geophysics4-4 |

| GIS Mapping | 5-1 | National Priorities List | 1-1 |
|-------------------------------------|---------|---|-----------|
| Granular Activated Carbon (GAC) | 6-16 | Natural Attenuation | 3-9, 6-4 |
| Groundwater Models | 5-2 | Natural Resources Trustee | 3-16 |
| Groundwater Treatment | 6-1 | NEPA Documentation, Programmatic | 3-4 |
| | | NFI Tour | 7-7 |
| Hazard Analysis | 6-20 | No Further Investigation (NFI)Designation | 2-2 |
| Hierarchy of Investigative Methods | 4-2 | | |
| Historical Surveys | 3-5 | OB/OD Sites, Using CERCLA to Close | 3-11 |
| Homestead Wells | 4-12 | Off-Site Wells | 4-13, 7-7 |
| HRA, Single Base-wide2- | 5, 3-15 | Operable Units, (OU), Number of | 1-2 |
| | | Operable Units, Prioritizing by Risk | 3-3 |
| IDW Plan3- | 13, 6-8 | ORC | 6-14 |
| Information Packet | 7-7 | Ordnance Management | 6-6 |
| Information Repositories, Off-Base | 7-1 | OU1, Changing Course | 3-2 |
| Information Repositories, On-Base | 7-1 | OU1, Test Bed | 3-6 |
| Innovative Investigation Techniques | 4-1 | Overburden, Clean | 3-13, 6-8 |
| Institutional Controls2-2, 2- | 3, 6-20 | Oxidizers, Evaluation of For Dioxin | |
| Interim Removal Action | | Formation | 4-11 |
| (IRA)2-3, 3- | 7, 3-15 | Oxygen-Releasing Compounds (ORCs) | 6-14 |
| Internal Combustion Engines | 6-17 | | |
| Internet, Documents on the | 7-6 | Passive Soil Gas Surveys | 4-6 |
| Interviews, With Retired Employees | 4-3 | Pentaborane Destruction | 6-2 |
| Investigative Methods, Hierarchy of | 4-2 | Perchlorate, Sampling of Off-Site | |
| In-Well Vapor Stripping2- | 3, 6-14 | Wells | 4-13 |
| IRP, Goal of | 2-1 | Perchlorate Contamination, Potential | |
| IRP Sites, Number of | 1-1 | Treatment of | 6-15 |
| IRP Strategy | -3, 2-1 | Preliminary Assessment/Site | |
| IRP, Transparent to Test Mission | 7-8 | Inspection | 2-1 |
| | | Presumptive Remedies | 1-5, 3-7 |
| Kiosk | 7-4 | Primary Documents | 3-15 |
| | | Prioritize OUs | 3-3 |
| Landfill Cover | 3-13 | Profiling, Seismic | |
| Landfill Closure | 6-3 | Programmatic Investments | 3-1 |
| Lead Agency | 1-4 | Programmatic NEPA Documentation | 3-4 |
| Long-Term Monitoring2- | 4, 6-20 | Programmatic Revegetation Plan | 3-6 |
| Long-Term Operation | 2-4 | Programmatic Section 7 for OU | |
| | | Investigations | 3-5 |
| MSR | 7-5 | Purge and Development Water, | |
| Management Action Plan (MAP) | -3, 2-1 | Minimization of | 6-18 |
| Methods, Investigative | 4-2 | Purpose of the Document | 1-3 |
| Micropurging | 6-18 | | |
| Model, Predictive | 5-2 | RAB, Formation and Training | 7-2 |
| Models, Groundwater | 5-2 | RAB "Tool Kit" | 7-3 |
| Mobile Free-Product Recovery Units | 6-11 | Ranking Sites | 3-14 |
| Monitoring Wells | 4-8 | Rapid Optical Screening Tool (ROST) | 4-7 |
| Monthly Status Reports (MSR) | 7-5 | RCRA Facility Assessment | 2-2 |

| RCRA – CERCLA Integration | 3-1 | Soil, Cleaned-Up | 3-13 |
|--------------------------------------|--------|--------------------------------------|------------|
| Recycling Soil3-13 | 6, 6-8 | Soil as Backfill | 3-13, 6-8 |
| Relative Risk2-2, | 3-14 | Soil Borings, Oversized | 4-8 |
| Remedial Investigation/Feasibility | | Soil Excavation "Scoop and Run" | 6-7 |
| Study (RI/FS) | 1-3 | Soil Farm, Operation of On-Base | 3-13, 6-8 |
| Remedial Project Manager (RPM) | 1-1 | Soil Gas Analyses, Active | 4-6 |
| Record of Decision (ROD)2-1 | , 2-5 | Soil Gas Analyses, Passive | 4-6 |
| Remote Sensing | 4-5 | Soil Removal | 2-3 |
| Removal Actions, Time-Critical3-10 |), 6-2 | Soil Vapor Extraction | 2-3 |
| Report to Stakeholders | 7-3 | SRAM Rocket Motor Removal | 3-10, 6-3 |
| Restricted Land Use | 2-3 | Stanford TCE Remediation | 6-13 |
| Restoration Advisory Board7-3 | 3, 7-4 | Strategies and Approach | 1-2, 2-1 |
| Retired Employee Interviews | 4-3 | Strategy, Simple Step-wise Cleanup | 2-1 |
| Reuse of Equipment | .6-19 | STAR Rig | 4-7 |
| Revegetation Plan, Programmatic | | | |
| Risk, Addressing | .3-13 | Techniques for Managing and Reducing | Risk6-1 |
| Risk, Relative Site Ranking | .3-14 | Teamwork | 1-4 |
| ROD, Single Base-wide | .3-15 | Team Building | 1-4 |
| | | Technology Testing | 1-5 |
| SACM | 3-2 | Test Bed, Use of OU1 as a | 3-6 |
| Sampling Off Base to Reassure Public | 7-7 | Time-Critical Removal Actions | 3-10, 6-2 |
| Sampling Perchlorate | .4-13 | Toxic Tours | 7-6 |
| Sampling, Technology Assessment, and | | Toxicity Reduction | 2-3 |
| Remediation (STAR) Rig | 4-7 | Tracer Studies | 4-9 |
| Schedule, Enforceable | | Trustee, Natural Resources | 3-16 |
| SCADA | .6-19 | | |
| "Scoop and Run", Soil Excavation | | Unexploded Ordnance (UXO) Managem | ent6-6 |
| Section 7 Consultation, Programmatic | 3-5 | Unrestricted Land Use | 2-2 |
| Seismic Profiles, 2D and 3D | 4-4 | UST Removal | 6-7 |
| Sensing, Remote | 4-5 | UXO on Active Range | 3-13 |
| Shallow Soil Risk Reduction Methods | 6-6 | UXO Sites, Addressing Risk | 3-14, 3-15 |
| Short-Range Attack Missile | 6-3 | UXO, Aerial Survey to Locate | 3-14 |
| Signatories | 2-2 | | |
| Site Closure | | Videos, Professionally Produced | 7-4 |
| Site Ranking | .3-14 | | |
| Site Summary Report | 3-8 | Web Site Address | 7-6 |
| Site Tours | 7-6 | Wells, Homestead | 4-12 |
| Skid-Mounted Equipment | .6-19 | Wells, Monitoring | 4-8 |
| | | | |